JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 20 OCTOBER, 1928 No. 4

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Discussion of all papers is invited

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CONTROL OF STRESSES IN PIPE LINE CONSTRUCTION[1]

BY LLOYD T. JONES[2] AND WALTER S. WEEKS[3]

A year ago the University of California published the results of a study of stresses in a large welded pipe line. For a complete account of the stresses, their measurement and analysis as of that date we refer you to that publication.[4]

We shall review briefly the stresses encountered in the construction of a pipe line and shall point out a new method for the elimination of the most important one of those stresses. This stress, which was primarily responsible for the failure of the Mokelumne Line, we did not then know how to eliminate. The method has not yet been announced.

The stresses which are met in construction may be divided into the following groups: 1, Line Stress; 2, Differential-Temperature Stress; 3, Residual Welding Stress.

1. Line stress. The stress thus designated will be best understood by referring to figure 1. It is evident that during the forenoon, under a rising temperature, several hundred feet of the pipe line will creep outward along the ditch due to compressive line stress. The stress at the free end is zero. At "B" the stress will be larger than at "A," at "C" still larger, etc. The line stress will be only that which

[1] Presented before the San Francisco Convention, June 15, 1928.

[2] Professor of Physics, University of California, Berkeley, Calif.

[3] Professor of Mining, University of California, Berkeley, Calif.

[4] A Physical Study of the Mokelumne Pipe Line, vol. 2, no. 9, University of California, Publications in Engineering, University Press, Berkeley, California.

is necessary to move the pipe against earth friction. During the late afternoon and evening the pipe will contract. During the process of retraction there is a tension in the line which I call line tension and which is equal to the frictional resistance of the pipe being pulled back. When the pipe stops contracting this tension remains in the line. As more pipe is added this tension remains and is built permanently into the line. It is present in riveted pipe lines as well as welded ones.

It is not due to any faulty method of construction and it can not be entirely eliminated. Its magnitude in a pipe line of large diameter may be 8000 pounds per square inch. Laying the line in groups of 20 sections each and joining the groups will reduce this stress to about half as much.

2. Differential-temperature stress is the stress due to the welding or riveting of a pipe line into a straight line at a time when there is a

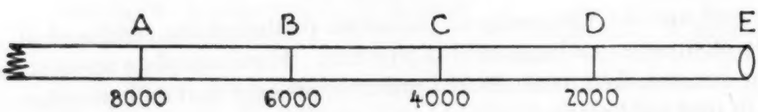

FIG. 1

Line stress at any point is the stress necessary to push or pull the pipe extending beyond that point. If the point no longer moves line stress remains at the value when motion last occurred.

difference of temperature of the top and bottom of the pipe. Differential-temperature stress in large lines is frequently due to a temperature difference as large as 50°F. This temperature difference produces a stress of 10,000 pounds per square inch which will exist in the top fibers when the pipe cools to uniform temperature. This stress can be eliminated by making all girth joints during those hours when top and bottom temperatures are equal. The few miles of Mokelumne Line whose girth joints were electric arc welded were made free of differential-temperature stress by welding at night. They did not break.

3. Residual welding stress. Those of you who may have read the results of the investigation of the welding of the Mokelumne Pipe Line will remember the emphasis placed on the seriousness of residual welding stress and may also remember the dismissal of the subject with the statement that in a line properly welded residual welding

stress should not exist. Residual welding stress is that stress which resides in the completed piece by virtue of the fact that it was joined by welding as opposed to any other method. This stress is due to the shrinkage that occurs in steel during its solidification and cooling to normal temperature. Residual welding stress may be perhaps best illustrated by figure 2, which represents two steel sheets being welded edge to edge, the distance apart is exaggerated. Instead of weld metal small coil springs are indicated as joining the two edges. At the start of the weld the metal deposited at "A" will solidify and will then act as a fulcrum. The metal next deposited at "B," "C," "D," etc., on cooling will produce tension to turn the two sheets about this fulcrum. Unfortunately the problem is complicated by the fact that the fulcrum continually advances.

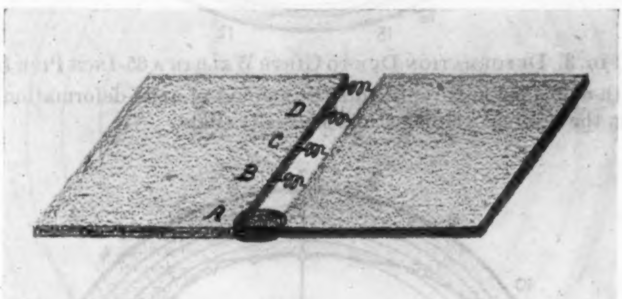

FIG. 2

The deformation produced in welding is due to expansion of the heated metal and the contraction, during solidification and cooling.

Figure 3 indicates the deformation in one of the welds of a 65-inch pipe. The deformation, and consequently the residual welding stress, is represented by the width of the shaded area. It was fairly uniform, the maximum being about 0.20 inch. A differential deformation of half this much, however, represented a stress of approximately 9000 pounds per square inch.

Figure 4 indicates the distortion which was produced by re-welding the upper half of one joint of a 65-inch pipe which had broken. The portion re-welded is indicated by the heavy black line. The deformation produced by the re-welding is plotted radially and indicated by the shaded area. The upper sheets of these two adjacent sections were drawn together a half inch, with the lower portion of the pipe

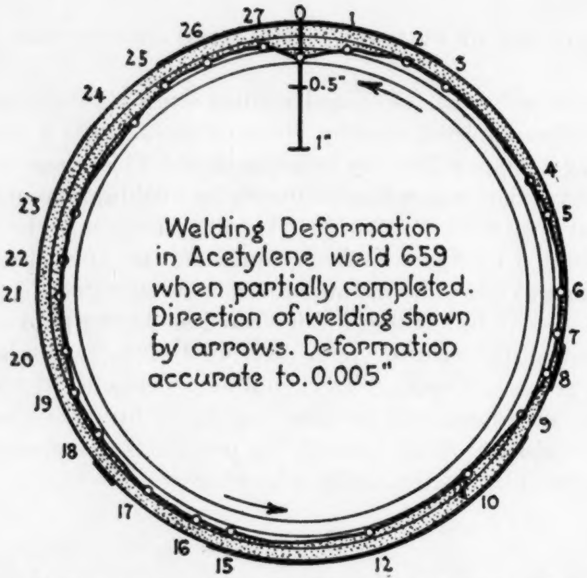

Fig. 3. Deformation Due to Girth Weld in a 65-Inch Pipe Line

▮ Width of shaded area represents the amount of axial deformation. If it is uniform the residual welding stress is usually slight.

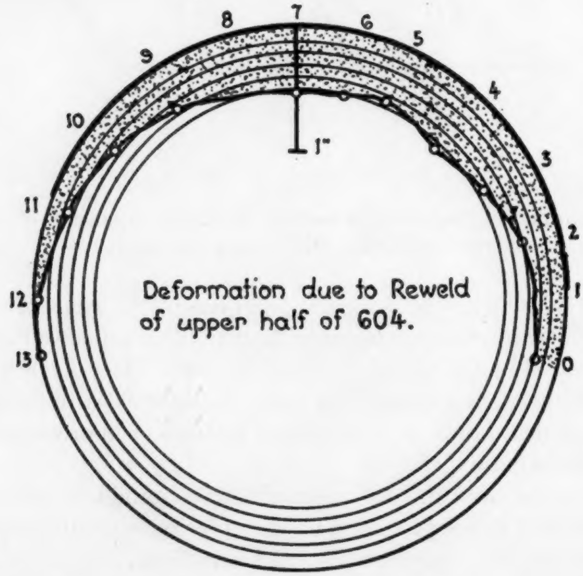

Fig. 4. Large Deformation in a Particular Reweld of a Broken Girth Joint

The parent metal of the pipe was permanently stretched

unmoved. It is important to remember that this metal was a half inch thick and the pipe 65 inches in diameter. This deformation indicates a stress far beyond the elastic limit of the metal. We indicate this merely to show the serious magnitude of stresses that may be introduced as residual welding stress. It may be of interest to you

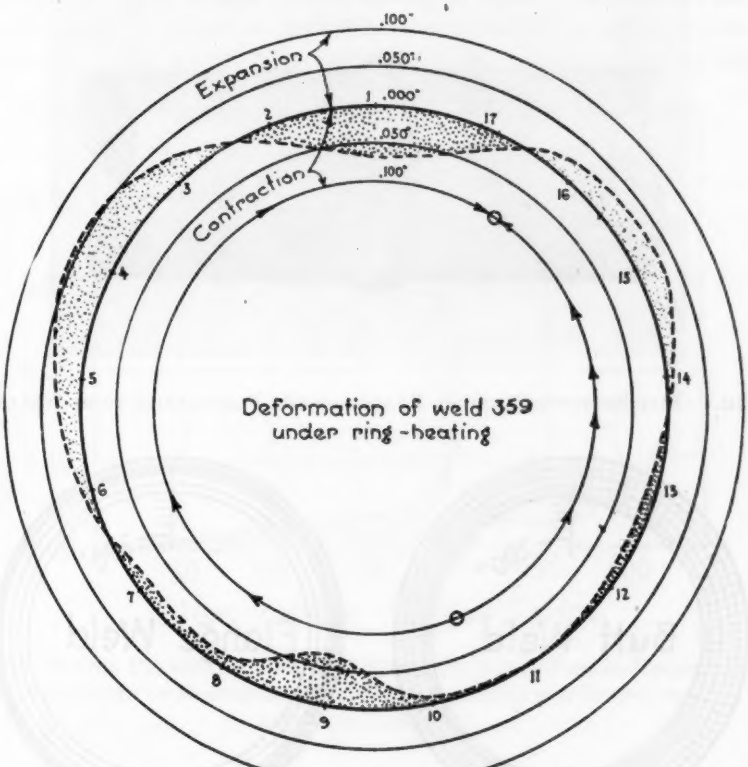

FIG. 5. RELIEF OF RESIDUAL WELDING STRESS AFFORDED BY SIMULTANEOUS HEATING OF WHOLE GIRTH WELD

to know that after that reweld was completed, even though this great stress was introduced the weld did not again fail.

There are three ways to produce pipe line girth welds without residual welding stress.

1. Figure 5 shows the relief of stress that was effected on one particular joint of the 65-inch pipe line by the simultaneous heating of

the whole weld. Ten acetylene torches were used to bring the whole weld to a uniform red heat. You will notice that in some places the weld metal elongated and in some places contracted, indicating that forces of tension and compression respectively had existed. While

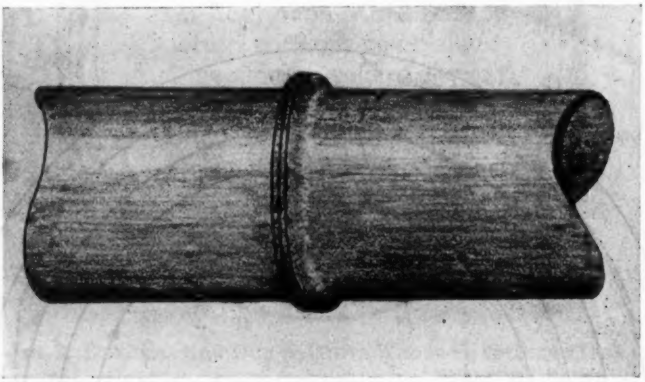

FIG. 6. PIPE SECTIONS FLANGED, READY FOR THE PERIPHERIES TO BE WELDED

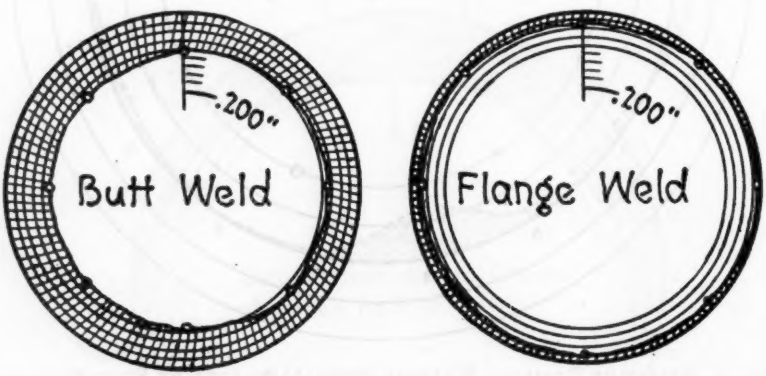

FIG. 7. COMPARATIVE DEFORMATIONS IN BUTT WELDS AND FLANGE WELDS IN 16-INCH BY ½-INCH PIPE

this method has the additional advantage of controlling the crystal structure of the weld metal, nevertheless we do not believe that it is economically feasible. While it is a possible method, it must nevertheless be disregarded.

2. A second method, however, is suggested by the discarded one. If it were humanly possible to produce the whole weld simultaneously

or to have the whole weld hot at the same time, it would be possible to produce a weld without serious residual welding stress. Although this has been accomplished on small diameter pipe it is not yet suitable for construction of large lines.

3. The third method for eliminating residual welding stress was brought to my attention by Mr. H. E. Kennedy. It is a method that is new, but we say immediately that we have the utmost confidence in it. We have measured welds which have been produced in this

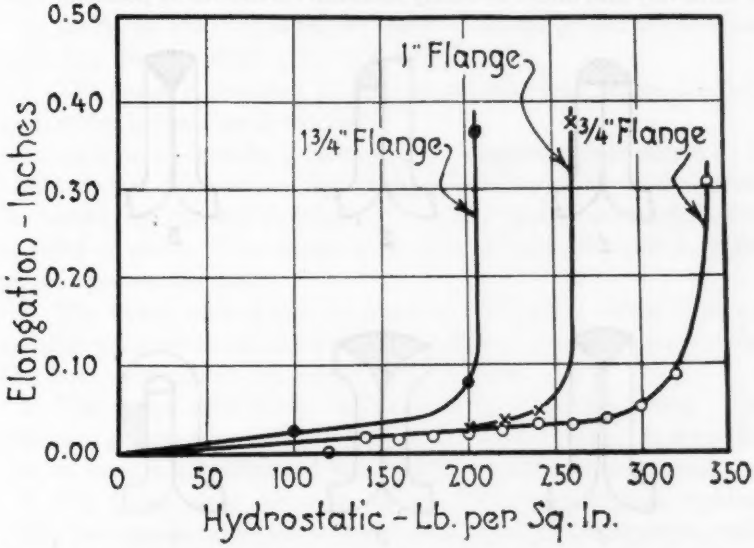

FIG. 8. WATER PRESSURE-ELONGATION TESTS ON 16-INCH PIPE TO DETERMINE THE WIDTH OF FLANGE NECESSARY TO WITHSTAND THE STRESS THE LINE IS TO UNDERGO

manner and we have found them to be with virtually zero residual welding stress.

Figure 6 shows adjacent ends of two pipe sections ready to be welded. Each is provided with a narrow flange rolled at right angles to the axis of the pipe. These flanges are placed with their faces in contact and then are welded along their peripheries. The design of the flange is dependent upon the conditions of stress the completed line is to be called upon to withstand. It is happily true that in this weld the residual welding stress is nearly zero. Several types of flange weld have been tested.

Before a detailed comparison is presented of the flange weld and its predecessor the butt weld, comparative values of the residual welding stress of the two types of weld on 16-inch by $\frac{1}{4}$-inch pipe are shown in figure 7. The tests on 16-inch pipe were made with the coöperation of Mr. R. S. Fuller and Mr. R. V. Wilson of the Pacific Gas and Electric Company. You will note that the deformation of the metal of the pipe proper is greater for the butt weld than for the flange weld. May I add the statement that these welds were both made by Mr. Hopkins the same day and under as nearly identical conditions as possible.

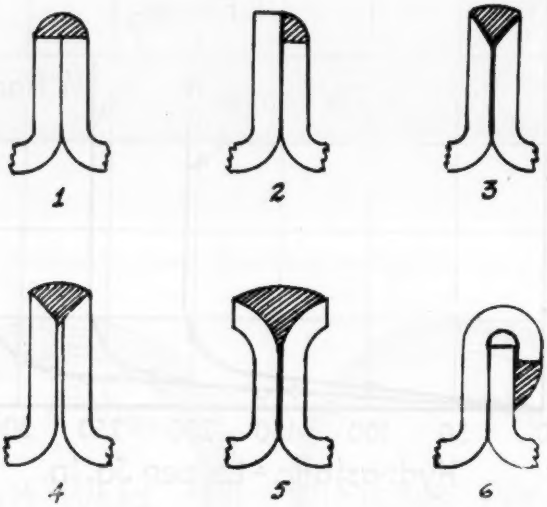

FIG. 9. TYPES OF FLANGE WELD

No. 6 is particularly suited for electric-arc welding

These values of deformations are not to be taken too literally. If sufficient time were taken to present the matter clearly it could be proven that in these two particular welds the stress in the pipe due to the flange weld does not at any point exceed 3480 pounds per square inch and that in one portion of the butt weld the stress is equal to the elastic limit of the parent metal. There seem to be two portions of this butt weld that are under compression, the two alternate portions being in tension.

The reasons why pipe line welds break and why they break only part way around and virtually never for the entire circumference are

indeed becoming quite clear. A detailed discussion must be postponed however till more time is available. In justice to butt welds it should be stated that this particular one is a beautiful weld and that it will never in the world fail, although the metal is severely stressed, because the weld is stronger than the parent metal.

Now let us make a more detailed comparison of the two types of welds.

1. In the butt weld the residual welding stress is in the plane of the pipe sheet.

In the flange weld it is at the periphery of the flange and can be transmitted to the pipe sheet only by the flange.

2. The flange is designed to yield by bending long before a serious axial stress in the pipe is reached.

In tests on 16-inch by $\frac{1}{4}$-inch pipe the elongation was shown to be 0.30 inch per joint before the flange weld showed signs of distress. No buried pipe line will ever be called upon to provide so much motion in relief of stress. The stress equivalent of this 0.30 inch is 40,000 pounds per square inch.

3. The flange weld is not an expansion joint, but rather is an expansible joint which can permanently elongate to relieve excess stress. The butt weld cannot elongate to relieve stress.

4. The flange weld lends itself admirably to group laying. The joining of groups is less difficult than with the butt weld. It is equally easy to remove a section and replace it as occasion may demand.

5. The flange weld not only affords relief from residual welding stress, but also it functions to relieve line stress, Poisson stress, cold-water stress and even differential temperature stress. The butt weld cannot relieve these four stresses.

6. With the flange weld there is no accidental formation of stalactites to impede flow.

7. The relative costs of the two types of weld may be judged from the fact that for the two welds in 16-inch by $\frac{1}{4}$-inch pipe the flange weld (not including the cost of forming the flange, since it was done by hand) was less than 70 per cent of the cost of the butt weld. Including the turning of the flange by hand it was only equal to the cost of the butt weld.

In this weld we have the utmost confidence and we might be accused of not telling the whole truth if we did not state that we consider it to be the most notable contribution to pipe line construction since the advent of welding.

DISCUSSION

WM. W. BRUSH:[5] We should certainly take advantage of the opportunities we have of obtaining further enlightenment on any point that may be doubtful in the minds of anybody here, because, speaking for myself, it has been a most interesting presentation of a subject that has engaged the attention of our engineering force for several years past.

It apparently never occurred to our designing engineers or to our construction group, to use a flange joint for the steel lines. That would enable us to utilize safely and effectively a joint that would give virtually 100 per cent efficiency, as against our riveted joint of approximately 55 or 56 per cent efficiency with a single line of rivets.

In the work that is carried on in the city streets, the circumferential joint is subject to stresses on account of the unstable foundation developed by excavation in the vicinity of the pipe line. It has for some time been my personal conviction that we should have a joint that would give us approximately the full strength of our sheet metal, instead of one that gives us about half that strength. My observation has been that the failure has come entirely in the circumferential joint. Those are the only failures that we have ever had in steel pipe lines, and we have had only two in the entire New York City system.

J. E. GIBSON:[6] I should like to ask Mr. Jones the width of the flange, and also if it is turned at right angles, or is at less than right angles to the axis of the pipe?

LLOYD T. JONES:[2] The design of the flange should be determined for each line. It will vary only slightly, perhaps, between different lines. The flange must be narrow enough so that it will not respond to every temperature, taking it beyond the elastic limit; yet it must respond to large temperature changes.

A large number of flanges have been tried. The flange in figure 9 goes all around the pipe; you are looking at the flange from the side of the pipe.

[5] President, The American Water Works Association; Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

[6] Manager and Engineer, Water Department, Charleston, S. C.

There are six types, and in each case the pipe is horizontal and this flange is vertical and passes around the pipe. Of these types of flange, all but one perhaps are suitable for acetylene welding. No. 2 is not so good. (Referring to flange numbers on figure 9.) No. 6 is particularly suitable for electric welding. In flange No. 1 you have two flanges, one on the pipe at your right, one at the left, both at right angles. We wish the flanges to be in contact at points other than their periphery, and then the peripheries welded. The flanges being welded prevent any deformation.

In type 4 the two flanges are not quite in contact for ease in welding; you can weld faster. But your flame gases in any one of the cases are shooting along the metal. So the inherent difference in the method of heating is the thing that makes the flange weld a very much more rapid weld to make.

No. 5 is a different modification. No. 6 is the one in which I think the greatest confidence will lie for joints under expensive streets, across a vacant lot, or under apartments. In this one, the flange is rolled out and then paralleled to the pipe, just like the bell and spigot joint. The other flange is inserted, and to tack weld it the welder warms the metal and presses it down a bit. Then, too, in completing the weld he merely drives the weld down. So you have parent metal that is taking the stress.

In No. 6 I have not yet been able to measure the elongation, because we ran to the limit of the measuring device and had to reset and go again. But that, I think, is far preferable to any of the other types of flanges for the particular case where you must not have a failure. That is, where you know you are going to have great elongation and must not have failure. But no pipe line will be called upon under normal conditions to stand an elongation greater than a tenth of an inch per joint.

Does that answer your question?

J. E. GIBSON:[6] Mostly, except what is the relative diameter of the pipe to the depth of the flange?

LLOYD T. JONES:[2] The depth of the flange is approximately independent of the diameter. The width of the flange, in most cases, would not be more than 2 inches. I am speaking now of 50 or 60-inch pipe. A flange width of four or five times the thickness of the metal is usually suitable.

J. E. GIBSON:[6] That is what I wanted to bring out.

E. L. MATHY:[7] May I ask your permission to say a few words, not as a member of this Association. But as a member of the welding industry, I would like to take this opportunity to say to you that Professor Jones has contributed something of tremendous value to the industry, to your industry and to the one of which I am a part.

In welding, whether electrically or gas, I believe that we have arrived at a point where we know how to make a weld. But I believe that we have stressed continuously a good weld to the point where it needs no further emphasis, because good welding and good welds can be executed.

However, I do not believe that we have laid any stress on the particular things that Professor Jones has called to your attention. Those are the things that are going to alleviate the difficulties we have experienced.

WM. W. BRUSH:[5] Professor Jones, are there any possible patent complications in the use of the flange?

LLOYD T. JONES:[2] I believe there are no complications whatever. While I believe it is patentable, I am sure there would be no difficulties about it.

WM. W. BRUSH:[5] As far as you know, there has been no attempt to have it patented?

LLOYD T. JONES:[2] I am certain that Mr. Kennedy, who introduced the idea to me, did finally secure a patent. But I am sure—I know I speak for him—that his greatest desire would be to have it useful. Mr. Kennedy and I are in a position to assist anyone who may wish to use it.

C. A. McCLAIN (Eugene, Ore.): There was developed the year before last, in connection with a 30-inch tee line, a joint somewhat similar to the one just shown, except that instead of a welded joint it was made with a band similar to a coupling. The man who had a great deal of welding experience in a local shop was used by our department

[7] Victor Oxy-Acetylene Equipment Co., San Francisco, Calif.

in inspection welding on this job. Because of the difficulty in getting the trench absolutely dry for the purpose of getting a good weld, he was conscientious enough to develop a joint similar to this, except that a band was placed around the edge of the band. The band was simply a piece of rolled rod, with a groove machined in it which clamped the ends of the flange together. I understand he has applied for a patent on that device and it is being used on a small line, which I believe is its first introduction.

His flange is not rolled at right angles. It is a great deal like the combination of the two figures at the left of figure 9. The flange is rolled at just a little less than 90 degrees to the axis of the pipe. If it started to beam that would provide for some expansion or contraction in every joint, as the case might be.

It appears to have some advantages over any type of welding joint in that it does not necessitate getting a trench absolutely dry, it may be applied by much less expensive labor than is required for the welding, and it also eliminates the expense of getting welding equipment over the ground.

LLOYD T. JONES:[2] May I again point out that this is not in any way an expansion joint. It does not attempt to provide expansion. There is nothing new about welding flanges in a flat sheet. There is even a flange weld for use on exhaust pipes where the flanges are welded for tightness and there is another flange bolted on for strength. The contribution that Mr. Kennedy introduced was merely the application of this particular flange to overcome the difficulty of residual welding stress in pipe lines. I do not consider the fact that it can be elongated of supreme importance in most pipe lines, because in most cases they will not be called on to elongate, but, nevertheless, the possibility to elongate is there.

WM. W. BRUSH:[5] Those of us who have used welded joints in a steel line have all felt some concern as to the stress which is left or set up in the metal, either in the weld or in the metal adjacent to the weld, as the result of the cooling of the deposited metal. I know we in New York have given a good deal of attention to it, and we believe that we have succeeded in getting joints reasonably free,—I am now speaking of the longitudinal joint—reasonably free of stress as the result of the methods of making up the joints, that have been fol-

lowed in the shop. This has been virtually laying up the metal in several layers.

We require coupons to be cut from the finished products and then bent in both directions to show the ductility of the weld. We believe that with the ductile weld and with the material deposited in layers we will not have any serious residual stress.

But the art is being constantly improved. We are all very grateful to members who are making investigations, such as Professor Jones and his associate, in pointing out how we can make certain that these stresses, of which we were afraid, will be eliminated, both in the longitudinal and the circumferential joints.

WATER SUPPLY OF LOS ANGELES[1]

By William Mulholland[2]

The selection of the site of the City of Los Angeles was dictated, as in the case of most cities, by the existence of an ample water supply to meet the needs of the people who sought to establish themselves there.

The early civilized discoverers of the country were the Spaniards and they found on their arrival here an aboriginal colony had been established there for manifestly a long period of time. The water supply was put to use by the semi-savage people who populated this section, who were a pastoral people, by the use of irrigating ditches and the production of crops over the broad area of flat land now occupied by the City of Los Angeles. These irrigating ditches were quite extensively developed before the arrival of the American population, the influx of which began about 1830 and was quickly followed by the advent here in rapidly increasing numbers from American and European sections, attracted largely, as were the original settlers, by the fertility of the soil and the abundance and reliability of the water supply. It seems an extravagance now to refer to this supply as being abundant, but considering the population in those early days, the Los Angeles River afforded one of the most attractive and abundant water supplies enjoyed by any community in Southern California and was found ample for the community up to the beginning of the present century when it was outgrown by the rapid development of the city and her consequent demands for water.

It must be remembered that the last four or five years of the past century produced a long and very severe drouth that extended into the years 1902 and 1903 and had the effect of lowering the usual yield of the Los Angeles River. This stream, which has its source largely in the Sierra Madre Mountains, had a reliable perennial summer flow of 75 to 80 second feet (approximately 51,680,000 gallons) but

[1] Presented before the San Francisco Convention, June 13, 1928.

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the six or seven successive dry years, 1896 to 1903, reduced the flow of the latter year to 43 second feet which had the effect of so arousing the people of the city that it was manifest to them that water had to be sought and introduced from some other source to provide for the rapid growth of the city.

The conjunction of many circumstances combined to bring this remarkable acceleration of growth. First, there is the attractiveness of the climate of the region. Second, there are facilities afforded by the building here of three transcontinental trunk lines. Coincident with all this came the discovery of oil in this region and then the extraordinary rich results of the products of the soil in the way of semi-tropic fruits and other products. With all these sterling advantages accruing to the prosperity of the city, it has to be admitted that aside from the one factor of oil the other elements depended more or less on the influence of the existing water supply which after all in a semi-arid country like this is a controlling influence of prosperity.

The growth of Los Angeles can best be gaged by giving the following list of census reports beginning with 1880 up to the present time:

YEAR	POPULATION
1880	11,183
1890	51,000
1900	101,000
1910	319,000
1920	634,000
1928 (Estimated)	1,300,000

In the years 1903 and 1904 as before stated, we had about reached the limit of the ability of the River in its then shrunken condition to supply the city with water. Fortunately there came a period of wet years immediately following, so with the existence of the ground waters developed in the neighborhood of the city it was able to carry on until 1913.

In 1904 Los Angeles vigorously set to work to secure an additional supply from the Owens Valley, from the east slope of the Sierra Nevada Mountains. This project, known as the Owens Valley Development, was the boldest attempt ever made to secure a water supply by any municipality. The distance required for the aqueduct was about 250 miles over three ranges of mountains and across deserts and other forbidding areas. The work was completed in 1913

and the water arrived here in the nick of time to save the city from grave disaster. This supply is an average equivalent of 350 second feet or 226,100,000 gallons of water per day, but its acquisition does not mean the end.

The city's growth by reason of the aqueduct and the stimulation of all industries due thereto, continues at an increasing rate and yet the water troubles are not over.

Los Angeles now has a population of 1,300,000 and is growing at the rate of approximately 80,000 per annum so it is quite apparent that it must immediately go about securing an additional water supply. The water supply can have but one source and that is the Colorado River. Once again the distance to be accomplished is over 250 miles across forbidding desert and over an elevation requiring 1600 feet lift. This will put the City of Los Angeles far and away in the lead of any city in the world from the point of difficulty and expense to secure an adequate water supply for her inhabitants.

In addition to this, the topography of the city is such that the water has to be supplied at many different elevations, ranging from sea-level to nearly 2000 feet above the sea, involving the expense of zoning at widely dispersed elevations of territory, which, of course, involves great mileage and intricate and expensive design of pipe system, together in some cases with costly pumping operations. We have emerged, therefore, from the original simple conditions when the city was supplied from the Los Angeles River wholly by gravity, to the present complex system requiring service over a territory with great differences of level.

The average supply derived from the Los Angeles River, as has been stated is 75 second feet and all of this was delivered by gravity to the people it served, so that the city was in a very envious position as to its domestic water supply. This water was collected in the watershed of the Los Angeles River having an area of 502 square miles. It supplies its own storage facilities in the deep gravel pits of the San Fernando Valley lying adjacent and immediately northwest of the city. In other words the yield which was 48,000,000 gallons per day or 95,618 gallons per square mile was served from the watershed, and this entailed no costly expense of reservoirs and was preserved in all its purity in the deep gravel pits above referred to, to yield by gravity as a constant stream into the Los Angeles River uncontaminated. It was due to these remarkably favorable conditions that the City of Los Angeles got its

start towards her ultimate prosperous future. It remains for the future inhabitants to compensate in the end for this kindly act of nature.

It must be borne in mind that the City of Los Angeles is geographically located in a very arid area. Except for the southwesterly boundary, which is the Pacific Ocean, it is for 40 or 50 miles from any direction, entirely surrounded by desert and for over 200 miles there is no available water supply within reach, except such as exists in the neighboring coastal plane. The closely adjacent communities are in the same fix as Los Angeles and must face the necessity of first developing to the utmost waters available at their doors and then following by excursions to great distances such as confronts the City of Los Angeles.

Already there have been complete surveys made looking to the Colorado River supply. Close research work has demonstrated that it is economically possible for the city to obtain this water at a reasonable cost. It remains only to have the Boulder Dam Bill approved by the Congress of the United States to start the city's work on this unexampled enterprise in the history of municipal organizations, but our people are fully keyed up to the enterprise and will, I am sure, as in the past, courageously support any project that has for its object the future permanent prosperity of the city.

CHLORINATED COPPERAS—A NEW COAGULANT

By L. L. Hedgepeth[1] and N. C. and William C. Olsen[2]

The following article describes a novel experiment with chlorine and a new development in water purification at Elizabeth City, North Carolina.

The raw water is taken from Knobb's Creek, a highly colored sluggish stream draining swampy territory in and adjacent to the Great Dismal Swamp. The color is present as negatively charged colloidal particles as determined by dialysis and cataphoresis and the intensity varies from 550 p.p.m. maximum to 150 p.p.m. minimum, and is 350 p.p.m. on the average. Production of an effluent of low color therefore presents a rather unusual problem in purification.

The local public suspicion of such highly colored water imposes upon the city officials the necessity of reducing this color to 10 p.p.m. and preferably to 7 p.p.m., before it is delivered to the consumers. A modern rapid sand filtration plant having failed to remove the color satisfactorily when the usual coagulation procedure was practiced, a series of experiments was undertaken by the writer as follows:

a. The bleaching effect of prechlorination. The results indicate that prechlorination applied five minutes prior to coagulation has no effect on color reduction unless applied in large doses—i.e., 10 p.p.m. or more.

b. The effect of prechlorination on coagulation. Chlorine applied prior to coagulation had no perceptible effect on coagulation. Doses from 0.1 to 10 p.p.m. were tried.

c. Cumulative and "split" application of several of the coagulants available for water purification.

1. A coagulating dose of alum and alkali followed by an alkaline aluminium compound, such as liquid or dry sodium aluminate, or premixed or simultaneously added alum and excess alkali. This was successful and has been fully described in a paper presented before the Southeastern Water and Light Association at Atlanta, Georgia, on April 18, 1928.

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[2] Consulting Engineers, Raleigh, N. C.

2. A coagulating dose of alum and alkali followed by enough alkali to raise the pH of the flocced water to the isoelectric point of aluminum hydroxide. The first floc formed at low pH values was peptized by the second alkali and the experiment was declared a failure as a color removal procedure.

3. A coagulating dose of copperas (ferrous sulphate) followed by an alkaline aluminum solution. The ferrous salt produced no coagulation and was useless as a coagulant in our water.

4. A coagulating dose of copperas oxidized to its ferric state by chlorine, i.e., "chlorinated copperas," followed by an alkaline aluminum solution. This experiment was even more successful than the alum-aluminate experiment. The remainder of this discussion is devoted for this reason to the details of the results produced by chlorinated copperas.

Herein "split" treatment signifies that two distinct dosages of coagulant are applied in the same mixing chamber and produce two separate and distinct precipitations. The procedure was as follows.

PRIMARY DOSE

Sufficient coagulant to give good coagulation of the coloring matter is quickly followed by sufficient alkali to maintain the pH value of the water at or near the isoelectric point of the compound being precipitated, which for our raw water seems to lie between pH 4.2 and 4.7. Sufficient contact is allowed in the mixing chamber for the formation of well defined floc particles, at a point less than half way through the mixing chamber.

SECONDARY DOSE

An alkaline coagulant which may be in the form of a commercial aluminate, premixed alum and alkali solutions in correct proportions to form an aluminate solution, alum and alkali added simultaneously or chlorinated copperas and alkali added simultaneously. Any of these combinations when added to the water at a point half way through the mixing chamber will cause a second precipitation to take place in the water carrying the primary floc and the effluent will be greatly improved in respect to color reduction and the elimination of residual coagulant in the effluent. Without the secondary application residual color will be present in objectionable concentrations in the plant effluent if the water coagulated at the low pH values of the

primary coagulation is filtered without application of a second coagulating dose such as described. This second coagulating dose effects removal of the more resistant coloring matter and insures the satisfactory precipitation of the metal of the coagulant. The zone of H-ion concentration in which this takes place most effectively is within the range pH 5.5 to 6.8.

Our plant is equipped with one Savage and three Wallace and Tiernan dry feed machines. During the experiment with the chlorinated copperas the copperas was fed from one of these machines, dissolved in a solution box with minimum amount of water necessary to complete solution and then merged in a single solution line with chlorine water supplied from a Wallace and Tiernan vacuum type chlorinator. The proportions were 1 pound of chlorine for every 8 pounds of copperas and complete oxidation of the copperas was accomplished effectively and almost spontaneously by this arrangement. The resulting solution was led into the inlet end of the baffled mixing chamber. As a control measure to insure effective oxidation of the copperas qualitative tests for the presence of ferrous iron were frequently made by adding potassium ferricyanide solution to samples collected at the discharge end of the solution line. Lime was also added at the inlet end of the mixing chamber to adjust the water to the isoelectric point (pH 4.2 to 4.7) of the iron coloring matter compounds formed. Coagulation was complete in the mixing chamber within five minutes or less, and at this stage a dose of commercial dry sodium aluminate, or "Alco Floc" was added to the flocced water to lower the hydrogen ion concentration and thus secure efficient precipitation of aluminum compounds. Most effective precipitations were secured in the zone of pH values 5.5 to 6.8. The formation of floc with ferric salts appears to be more rapid than with alum.

Correct doses were determined by a series of three jar tests, the first to determine the lowest permissible chlorinated copperas dose, the second to determine the optimum amount of lime to improve the iron colored floc, and the third to determine the amount of alkaline coagulant necessary to secure a filtrate containing the minimum residual color and soluble coagulant. Floc appearance, color, and residual iron were determined in the filtrate through absorbent cotton from the most promising of the final set. This was done in order to secure refined differentiation between one or more combinations which had apparently produced equal results as far as floc appearance would indicate.

During the period covered by the plant scale experiment with chlorinated copperas we were handling a water well above normal in color content. The raw color was 550 p.p.m. and we were using 4.75 grains of alum per gallon, 12 p.p.m. lime, and 15 grains per gallon of sodium

TABLE 1

Plant cost data

	CHLORINATED COPPERAS, LIME AND ALUM RUN	CHLORINATED COPPERAS, SODIUM ALUMINATE RUN	ALUM AND SODIUM ALUMINATE
Gallons water treated	2,000,000	735,000	1,000,000
Pounds copperas used	930	342	None
Cost @ $1.02 per cwt	$9.49	$3.49	
Pounds alum used	None—500	None	680
Cost @ $1.36 per cwt	$6.80	0.00	$9.25
Pounds chlorine used	114	43	3
Cost @ 7.5¢ per lb.*	$8.55	$3.22	$0.23
Pounds sodium aluminate used	None	84	214
Cost @ $3.51 per cwt		$2.96	$7.54
Pounds lime used	383	79	100
Cost @ $0.72 per cwt	$2.76	$0.57	$0.72
Wash water used	17,500	6,743	8,150
Cost @ 3.2¢ per 1000 gals	$0.56	$0.21	$0.28
Total cost	$28.16	$10.45	$18.02†
Cost per million gallons	$14.08		$18.02†

* Chlorine cost for less than car shipments. This item much smaller for larger consumption.

† This treatment was used during heavy color of raw water. Average plant cost of lime, alum, sodium aluminate method slightly less than $11.00 per million gallons. The chlorinated copperas treatment was used during the same period and the costs, although above average, compare for same quality of raw water.

aluminate. The color of the filter effluent with this dose was 7 p.p.m We selected from our jar tests as described above 4 grains per gallon of chlorinated copperas, 3 p.p.m. lime, and 0.75 grain of dry sodium aluminate as the lowest dose which would produce a filtrate containing 7 p.p.m. or less color.

After changing the plant from the lime-alum-aluminate treatment to the chlorinated copperas-lime-aluminate treatment we soon had superior coagulation and, after a twenty-four hour run, substituted 1.75 grains of alum, and 20 p.p.m. lime as the secondary dose to replace 0.75 grain of dry sodium aluminate. Equally satisfactory results were obtained from the alum-lime secondary dose as were produced by sodium aluminate. During the same day the chlorinated copperas dose was reduced from 4.0 to 3.5 grains per gallon with no less satisfactory results. Later we dropped the chlorinated copperas dose to 3.25 grains per gallon with satisfactory results. It is probable that a lower dose of chlorinated copperas would have proved satisfactory, but exhaustion of the copperas supply caused the run to be discontinued before this change could be made. The experiment lasted seventy-five continuous hours. Three filters were operated at 300,000 gallons per day rate each. Starting with 1 foot loss of head, at the end of the seventy-five hours operation 5.5 feet loss of head were recorded and no filters were washed.

A marked improvement in the taste of the plant effluent was noticed and was the subject of numerous inquiries from consumers who were not aware that a change in treatment was being tried. We noticed during this experiment and during our prechlorination experiments a lessening of the tendency of the sludge to putrefy and rise to the surface of the coagulation basins. This improvement in basin condition probably had some bearing on the improvement in the taste of the filtered water.

The figures in table 1 show comparative coagulant costs during and prior to the run with chlorinated copperas.

SUMMARY AND CONCLUSIONS

1. Copperas (ferrous sulphate) and lime are not satisfactory coagulants at Elizabeth City, N. C., unless the copperas is oxidized to its ferric state.

2. Prechlorination with reasonable doses does not improve coagulation of the highly colored water at Elizabeth City, N. C., when applied in the mixing chamber.

3. Prechlorination reduces the tendency of the sludge in the coagulation basins to ferment.

4. Single coagulation with any of the coagulants employed is not satisfactory because of the color and residual coagulant left in the filter effluent.

5. To produce an acceptable filter effluent "split" application of coagulants is essential. The primary coagulation must take place between pH 4.2 and 4.7, and the secondary coagulation between pH 5.5 and 6.5.

6. Copperas, completely oxidized with chlorine in the ratio of one part of chlorine to 7.8 parts copperas, produces a coagulant superior to alum in color removal qualities and is more economical because of its higher efficiency.

7. A combination of chlorinated copperas, alum and lime or sodium aluminate produces an attractive and economical filtered water as evidenced by comments of consumers and cost data.

8. Conversion of ferrous sulphate (copperas) to the ferric state is readily accomplished by introducing chlorine water from a chlorinator into the discharge line from the copperas feeding machine or solution tank. The reaction between the copperas and the chlorine is practically instantaneous, requiring less than 20 feet of travel for completion.

Acknowledgment is made to:

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CHLORO-PHENOL TASTES FROM CREOSOTED WOOD STAVE PIPE[1]

By Dana E. Kepner[2]

Conditions particularly favorable to the use of continuous wood stave pipe prevail in Colorado, as in many other of the western states. In consequence thereof mile after mile of such pipe has been laid to carry mountain water to cities for domestic supplies from more or less distant sources.

Until a few years ago practically all of the wood stave pipe laid was made of untreated lumber, the use of which was found to have no effect on the physical quality of the water regardless of any purification process employed. Of late, however, the use of creosote as a wood preservative has been adopted by some of the wood pipe manufacturers, and several installations of creosoted wood stave pipe have been made. The use of the pipe has been found to produce tastes in the water for a time, particularly offensive and particularly lasting in certain cases where chlorination of the water is practiced.

LOVELAND

Experience at Loveland, Colorado, with the use of creosoted wood stave pipe to carry filtered and chlorinated mountain water 8 miles from the purification plant to the city, was described by Osborn in a paper read before the Rocky Mountain Section in 1927 and published in The Journal.[3] There it was found that, whereas the treated water at the plant had no offensive taste, nor developed such upon standing, the water flowing through the creosoted wood supply main developed a typical chloro-phenol taste.

The taste was quite intense when the pipe was first placed in service in the summer of 1924, even though it had previously been

[1] Presented before the Water Purification Division, San Francisco Convention, June 14, 1928.

[2] Director, Division of Sanitary Engineering, Colorado State Board of Health, Denver, Colorado.

[3] Journal, 17: 5, May, 1927, pp. 586–590.

flushed out continuously for about six weeks, and it had almost the same intensity in samples taken from various points along the line. After a few months it became practically unnoticeable in the water drawn from the main about a mile below the plant, but was present at points further along, the intensity increasing with the distance from the plant and being at a maximum in the city. It persisted in the city water for three years, until the winter of 1927 when the point of application of the chlorine was changed from the filter effluent to the settling basin inlet.

During the spring and summer months of 1925, 1926 and 1927, when the raw water contained more suspended matter and the filtered water, judging from its chlorine demand, contained more organic matter, the taste in the city water was much less intense than during the other months of these years, being almost unnoticeable during the summer of 1927.

Upon returning the chlorinator to the filter effluent this past spring, necessitated by the fact that the amount of chlorine required for pre-chlorination became greater than the capacity of the machine, the taste did not reappear. The chlorine dose used when treating the raw water was sufficient to produce a residual of 0.10 p.p.m. after about four hours contact in the sedimentation basin, but none after filtration. When chlorinating the water after filtration the dose used was such as to produce a residual of 0.10 p.p.m. after ten minutes contact. An experiment with increased chlorine dosages after filtration during the winter of 1926 resulted in even more intense taste.

It is interesting to note in connection with this Loveland case, that a few months before the new creosoted wood supply main was put in service, an offensive chloro-phenol taste occurred in the treated water at the city at the time that a 2-mile creosoted wood stave pipe line, 36 inches in diameter, was put in service supplying water to the new Loveland hydro-electric plant located on the river about 10 miles above the water works intake. This taste lasted several weeks.

CANON CITY

At Canon City, Colorado, a 30-inch continuous wood stave pipe installed some twenty years ago carries Arkansas River water, from an intake just above the famous "Royal Gorge," about 10 miles to a purification plant located on a hill above the city. The purification consists of coagulation and long time sedimentation, followed by

slow sand filtration, chlorination, and detention in duplicate clear water basins.

This pipe line carries not only the water for the domestic supply at Canon City, but also, in the summer season, water for farm irrigation amounting to two or three times that of the city supply. It is laid for the most part above ground, in many places suspended by steel brackets from the sheer rock wall of the Gorge. In the winter the water in the pores of some of the wood staves freezes, expanding and separating the wood fibres. Repeated freezing and thawing has made the wood quite soft and sponge-like, necessitating comparatively early replacement of staves.

On the assumption that staves penetrated with creosote would not absorb sufficient water to result in damage by freezing, the city water department determined in 1926 to make future replacements with such material. In the early spring of 1927 about 1000 feet of this pipe were replaced with creosoted staves, and coincident with this there began a siege of chloro-phenol taste in the city water. In this case, increasing the chlorine dosage from the normal of about 3 to 6 pounds per million gallons apparently reduced the intensity of the taste.

About three months after the taste siege began, the additional water for farm irrigation was turned into the pipe line, and taken out at the purification plant inlet, upon which the taste left the city water completely. The quality of the water flowing through the pipe also changed about the same time, becoming more turbid and carrying more organic matter.

In the fall of 1927, when the irrigation water was shut off, and when the quality of the water returned to its winter status, the taste did not recur,—nor did it recur during the following winter and spring of this year upon the installation of a few hundred feet more of the creosoted staves.

The majority of the complaints from the consumers during the taste siege at Canon City referred to the effect on tea and coffee made with the offending water. A large tea and coffee store suffered considerably, needless to say.

PUEBLO

At Pueblo, Colorado, there are two similar but entirely separate municipally owned water systems, one serving the northern half and the other the southern half of the city. Both obtain water from the

Arkansas River through nearby intakes at the upper city limits and both employ coagulation, sedimentation and chlorination, the north side plant providing an average of about ten days detention, of which one-half day is following chlorination, whereas the detention at the south side plant averages about three days, none of which follows chlorination.

The Arkansas River receives at times small amounts of phenols from several sources, including a selective flotation mill at Leadville using cresylic acid; a creosoting plant at Salida, where creosote from the piles of treated lumber drips onto the ground and no doubt reaches the river nearby, through the ground water flow rather than surface run-off because of the great porosity of the gravel river bank on which the plant is located; a small gas plant at Canon City; and an oil refinery at Florence. These phenols in the river water have on numerous occasions been the cause of offensive chloro-phenol tastes in the chlorinated water at Pueblo, appearing on the south side first, due to the shorter detention of the water at the south side plant, but, for the same reason, lingering longer in the north side water.

About three years ago the south side water works installed a creosoted wood stave pipe line, part 30 and part 24 inches in diameter, extending from the pumping plant some 3 miles to a standpipe and being connected at several places with the distributing system. Before the main was actually placed in service water was pumped through it to an artificial lake for recreational use for a period of about six months.

In spite of the complexity of the problem introduced by the intermittent phenol pollution of the river water, the effect of the south side's creosoted wood force main has been apparent at times for over a year since it was placed in service. This is seen by the production of typical chloro-phenol tastes in the south side water whenever the chlorine, introduced just before the water enters the pumps and goes to the consumers, is administered in such quantities that 0.05 p.p.m. or more of residual chlorine is found after five minutes' contact, at times when no phenol river pollution is indicated. A considerably higher residual chlorine content can be maintained in the north side water, in the absence of phenol river pollution, without causing a taste in the water. It is believed, therefore, that by changing the point of application of the chlorine on the south side supply so as to provide a few hours detention after chlorination, the residual chlorine resulting from a dose adequate for safety would vanish before the

water entered the pipe, eliminating any future production of taste due to this pipe.

In March of this year during a long siege of tastes in the water of both the north and south side supplies at Pueblo, ranging from oily to chloro-phenol and due no doubt to river pollution, pre-chlorination was tried at the south side plant. About 7 pounds of chlorine per million gallons was used, resulting in a residual of 0.10 p.p.m. after ten minutes' contact. The result was disastrous, a much more intense taste being produced in the treated water. No taste had developed, however, in samples of the water obtained ten minutes after the chlorine application.

FORT COLLINS

At Fort Collins, Colorado, 1700 feet of 30-inch creosoted wood stave pipe was installed in 1926 to carry water from an intake in the Cache la Poudre River to the new purification plant, which comprises coagulation, sedimentation, mechanical filtration and chlorination. The creosoted pipe was well flushed for several days before being placed in service, and no chloro-phenol taste has been noticed in the chlorinated water. This pipe is apparently too short to introduce into the water flowing through it sufficient creosote to produce the characteristic taste upon subsequent chlorination of the water.

DURANGO

At Durango, Colorado, 2 miles of 18-inch creosoted wood pipe, in assembled sections rather than continuous staves, was installed during the summer of 1927 and placed in service in August of that year without any appreciable prior flushing. This carries water, originally obtained from a mountain stream, from one storage reservoir to another, and from the latter the water flows immediately to the city. For several days after this pipe was put in service a most disagreeable plain creosote taste was present in the water. At that time, anticipating the installation of a chlorinator at the discharge end of this creosoted wood pipe, an experiment was made by diluting the creosote-tasting tap water with distilled water until the creosote taste was not noticeable and then chlorinating this mixture with a calcium hypochlorite solution so as to result in 0.10 p.p.m. residual chlorine after ten minutes' contact. A decided chloro-phenol taste developed in the sample in the course of about five minutes

and remained until it was discarded several hours later. This indicated that such a taste might develop in the city water if chlorination was practiced, even after the amount of creosote in the water had become too small to be noticed of itself.

EXPERIMENTS

At different times during the past two years experiments have been conducted at several cities to determine the possible production of chloro-phenol tastes in the water of their respective supplies when samples were impregnated with traces of creosote, and chlorinated. At each of the cities where the tests were made, namely, Canon City, Colorado Springs, Denver, Durango, Fort Collins, and Pueblo, a decided chloro-phenol taste developed in samples of one glassful when very small splinters from creosoted wood pipe staves and railroad ties were quickly immersed and withdrawn and the water then chlorinated. Likewise the taste developed in all of the waters when they were chlorinated prior to the introduction of the creosoted splinter, provided residual chlorine of about 0.05 p.p.m. or more was present when the splinter was introduced. In no case did the taste develop when the water was similarly chlorinated but the creosoted splinter not introduced.

SUMMARY

Summarizing the data offered by these experiences, we find that certain waters coming in contact with relatively new creosoted wood pipe and treated either previously or subsequently with chlorine in amounts customary for sterilization, develop a characteristic chloro-phenol taste, whereas the same waters similarly chlorinated but not coming in contact with such pipe do not develop the taste. Among the factors apparently influencing the formation of the taste are: the amount of organic matter in the water, the less present the more decided the tendency for taste to develop; the amount of residual chlorine in the water as it enters such pipe, in the case of prior chlorination; and the several factors which determine the amount of creosote taken up by the water in passing through the pipe, such as the newness of the pipe in point of service, and the amount of contact.

WATER HARDNESS, ITS EFFECTS AND ITS REMOVAL[1]

By Rudolph E. Thompson[2]

A hard water, popularly speaking, is one with which it is difficult to obtain a soap lather. To understand this we have to become somewhat familiar with the nature of soap; and we can best do this by considering for a moment how it is manufactured. The raw materials are essentially animal or vegetable fats and oils, such as tallow, palm oil or olive oil, and caustic soda. When the oil and caustic soda are mixed under certain conditions, the soda combines with the oil forming the sodium salts of the respective fatty acids. These compounds are known as soaps.

The oils form soaps with other alkalies also, the nature of the soap being dependent on the alkali used. If soda is used, as above, a hard soap is produced which can be pressed into cakes; if potash is used, we obtain the familiar soft soap; and if lime or magnesia are used, the soap which is formed will not dissolve in water and is therefore of no use for cleansing.

Now this is exactly what occurs when soap is used with hard water. The soluble sodium soap is changed into the insoluble calcium or magnesium soap, and lather is not obtained until sufficient soluble soap has been added to convert the hardness into insoluble soap. This insoluble soap collects on the sides of washbasins in the form of curds, with which we are all familiar. We are, in reality, softening the water with soap before using it.

Water, in its original state as it falls from the heavens as rain or snow, contains very little matter in solution except atmospheric gases. Thus rain water is soft, that is, it will lather immediately with soap. As this water flows through underground and surface channels to join larger bodies of water it rapidly dissolves hardness salts, together with other impurities, from the rocks, etc., with which it comes

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in contact. In the case of surface waters, industrial wastes also contribute to the hardness.

The chief hardness salts are the carbonates, bicarbonates and sulphates of calcium and magnesium. In addition to these compounds, iron and aluminum salts and other substances also add to the hardness, but these are relatively unimportant from this standpoint, although of great importance in other regards.

TEMPORARY AND PERMANENT HARDNESS

Calcium carbonate, which is simply limestone, is only slightly soluble. In other words, pure water will dissolve only a small amount —about 15 p.p.m. (1, 2). When carbon dioxide is present, however, which is invariably the case, being a constituent of the atmosphere and a product of decomposition, it is converted to calcium bicarbonate which is more soluble. Water, then, with the aid of carbon dioxide, carries in solution a great deal more calcium carbonate than could remain in solution if the carbon dioxide was removed. When water containing this type of hardness is boiled a considerable amount of carbon dioxide passes off with the steam, and as a result calcium carbonate separates as a solid deposit. If this process was carried to completion there would remain in solution only the small amount of carbonate which is truly soluble. The best example of this can be found in our homes in the humble tea-kettle. The deposit which collects on the sides and bottom is chiefly calcium carbonate which was carried in solution until carbon dioxide was driven off during the boiling of the water.

The fact that this type of hardness is so easily deposited gives rise to the term temporary hardness, which distinguishes it from the remaining carbonate and the sulphate hardness, which are unaffected by boiling and are therefore known as permanent hardness.

The above described phenomenon is true also of the corresponding magnesium salts, but the softening effected is less, owing to the greater solubility of magnesium carbonate—100 p.p.m. (3).

EFFECTS OF HARDNESS

The effects of hardness are many and varied. The most important from the standpoint of the domestic consumer is that to which we have already referred, namely, soap waste. Buswell (4), in an excellent discussion of the subject, shows that the theoretical loss is about $\frac{1}{20}$ pound of soap per 1000 gallons for every part per million of hardness

and that laundry experience indicates a loss of about $\frac{1}{10}$ pound per 1000 gallons. He estimates that a ton of soap is wasted every day in a community of 40,000 people using a water with 300 parts per million of hardness.

Most authorities state that the saving in soap alone is greater than the cost of municipal water softening. Thus at Lansing, Mich., Eldridge (5) estimates that with a hardness of 380 p.p.m. the annual soap loss is $134,000, while the cost of softening would be only $103,300; and at Madison, Wis., White (6) estimates the soap waste to be $67,890 per annum and the cost of softening only $38,225.

The average per capita use of water for washing is usually estimated at one gallon per capita per day, or less than 1 per cent of the total water supplied. The value of soft water in laundering can therefore be readily appreciated. It is probable that most laundries, particularly those of appreciable size, employ softening where the community supply is hard. In addition to the economy effected, difficulties due to staining by the insoluble soaps formed, which are not easily removed from the fabrics, are avoided. It is of interest to note in this connection that Strout (7) reports that clothes washed in soft water have an increased life of 25 to 100 per cent.

Another field in which the savings that may be effected by water softening are very great is in boiler practice. To deal with this phase of the subject in an adequate manner would require much more time than is available and we will therefore content ourselves with a few brief references to it. In this case the effect of hardness is to cause increased fuel consumption by the formation of scale on the heating surface of the boiler, as in the illustration of the tea-kettle previously given. The permanent hardness also enters into the problem as the concentration increases to such an extent by the continual addition of fresh water that the solubility of these salts is far exceeded.

Parr (8) states that a conservative estimate of the loss of fuel would be 10 per cent for each $\frac{1}{16}$ inch of scale, while Rankine (9) estimates the loss at from 16 per cent for $\frac{1}{6}$ inch of scale to 150 per cent for $\frac{1}{2}$ inch.

Coughlan (10) reports that railroads have found water treatment to be an important means of reducing operating costs. He quotes from the Railway Engineering and Maintenance Encyclopedia to the effect that approximately 1000 water softeners are now operated by the railroads of the United States, removing 100,000,000 pounds of scale annually at a saving of about $13,000,000 per year. Grime

(11) states that a leading Eastern railroad estimates the annual loss in fuel and maintenance costs due to unsuitable water to be $3,000,000. These data indicate the enormous savings that may be effected in boiler operation by water treatment.

There are also serious objections to the use of hard water in various industrial processes. Thus hard water causes loss of dyes in the textile industry, waste of tannin and other chemicals in tanning operations, toughening of canned vegetables and increased use of size in paper manufacture. It also gives rise to unsightly cores in artificial ice cakes, and introduces complications in the scouring of textile fibres.

Some years ago goiter and certain diseases of the kidneys were attributed by investigators to the domestic use of hard water, but it is now generally conceded that, within reasonable limits, there is little connection between the hardness of the water supply and the health of the community (12, 13).

SOFTENING METHODS

In 1841, Dr. Clark, of England, discovered that temporary hardness could be largely removed from water by addition of lime. This is simply another means of removing the carbon dioxide which enables calcium carbonate to remain in solution. The lime combines with the carbon dioxide forming more calcium carbonate, which, together with that originally present, separates as a white solid. The small amount which is truly soluble, of course, remains in solution.

Magnesium carbonate can be removed in a similar manner, but, as its solubility is considerable—100 p.p.m.—the process must be carried further. This is accomplished by applying an additional equivalent of lime, which decomposes the magnesium carbonate, forming calcium carbonate and magnesium hydroxide. The latter, being nearly insoluble—6.4 p.p.m. (14)—is deposited with the calcium carbonate.

A very great advantage of the Clark process is that the softening reagent is deposited with the temporary hardness. There is no new compound formed which remains in solution, and, consequently, the total amount of substance in solution is reduced approximately to the same extent as the hardness. This cannot be accomplished in the case of calcium or magnesium sulphate, which, as previously explained, are the chief permanent hardness salts.

The chemical employed for the removal of permanent hardness is

sodium carbonate, commercially known as soda ash, which decomposes the calcium and magnesium sulphates, forming sodium sulphate and calcium and magnesium carbonates. As in the case of the temporary hardness, the magnesium carbonate must be converted to the hydroxide, which will settle out with the calcium carbonate. The sodium sulphate, being very soluble, remains in solution. As the sodium combining weight is greater than that of either calcium or magnesium, the total amount of substance in solution is actually increased.

This method, which was discovered by Porter, is widely used in conjunction with Clark's lime treatment under the name Clark-Porter process, or, more commonly, the lime-soda process. The amounts of lime and soda ash required can be calculated from an analysis of the water to be treated. After adding the necessary chemicals and agitating for the desired length of time, the water is passed through settling basins to remove the precipitated hardness. The period of sedimentation allowed varies at different plants according to the composition of the water and other factors. From four to twelve hours is usually sufficient. The temperature of the water is important, low temperatures tending to retard the chemical reactions involved. The use of clarifiers facilitates the removal of the sludge.

Unfortunately the application of the lime-soda process in practice is not always as simple as the foregoing outline would indicate. One of the difficulties encountered, particularly with waters high in magnesium, is that maximum reduction of hardness can only be effected by the use of chemicals in excess of the theoretical amounts necessary. Several modifications have been introduced to overcome such complications. Hoover, of Columbus, Ohio, who has been very active in this connection, believes the incomplete reactions to be due to the formation of complex basic carbonates or colloidal precipitates (15).

The modifications which have been devised to cope with this situation include split treatment, return of excess sludge and the use of coagulants. Split treatment consists in overtreating the major portion of the water with lime and soda ash, thus effecting maximum reduction of hardness, and then neutralizing the excess of chemicals with the remainder of the water. The effects of returned sludge and of coagulants are described by Bull (16) and Hoover (17) respectively. Both methods aid sedimentation. In municipal plants, softening below 60 to 75 p.p.m. is seldom attempted.

Another difficulty encountered is the formation of carbonate deposits on the filter sand and in the distribution system following treatment. This is due to the fact that deposition of the carbonates is not complete when the water leaves the sedimentation basin. The remedy is to apply carbon dioxide to the water just prior to filtration. In principle, this process, which is known as recarbonation, is just the Clark process reversed. Thus lime treatment consists of removing carbon dioxide so that the carbonates will precipitate, while recarbonation consists of adding carbon dioxide so that the residual carbonates will remain in solution. The carbon dioxide is usually generated by burning coke, oil or gas in a suitable apparatus.

Lime treatment, if carried far enough, in addition to its softening action, is an effective means of sterilization. Several plants in Ohio, where difficulties due to chlorophenol tastes are prevalent, are using this method instead of chlorination. Owing to its property of removing carbon dioxide, which is essential to plant life, lime is also an efficient algaecide.

SOFTENING BY BASE EXCHANGE

Another method of softening water is that known as zeolite treatment or base exchange, which consists of passing the water through a filter containing zeolite sand instead of silica sand as in ordinary filters. Zeolites are compounds of aluminum, silica and sodium (or potassium), which occur in nature or can be prepared artificially. They possess the property of being able to exchange their bases for others with which they come in contact. Thus, for example, when water containing calcium carbonate is passed through a bed of zeolite the calcium is retained and the sodium of the zeolite is substituted for it, the effluent containing sodium carbonate instead of calcium carbonate. Any type of hardness, calcium or magnesium, temporary or permanent, can be removed by this process.

When the base exchange power of the material becomes exhausted the filter is removed from service and the process reversed. A solution of common salt, which is sodium chloride, is passed through the bed, the sodium being retained by the zeolite and the calcium or magnesium liberated, the latter flowing to waste with the spent salt solution. The filter is then ready for service again.

There are a number of base exchange materials on the market, such as permutit, permutit B, doucil, kenzelite, etc., which differ in chemical and physical structure, but the principle of their action

is the same in each case. The amount of salt required for regeneration varies somewhat, but is usually $\frac{1}{3}$ to $\frac{1}{2}$ pound per 1000 grains of hardness removed.

A water of practically zero hardness can be produced by this method, but, as in the case of removal of permanent hardness with soda ash, the content of total solids is increased to a certain extent. The high concentration of sodium salts in the treated water, which is directly proportionate to the original hardness, may be objectionable in some cases, as these salts are believed to be a contributory cause of foaming in boilers. Any impurity, such as suspended matter, iron, oil, etc., which would tend to form a deposit or film on the zeolite grains must be removed before this method can be applied.

LIME-ZEOLITE METHOD

An interesting combination of the two methods described above is being experimented with at Columbus (18). Studies have indicated that temporary hardness may be removed more economically by lime treatment than by the zeolite method, while permanent hardness may be removed by the zeolite process at about one-half the cost of soda ash treatment. The method proposed is treatment with lime and alum, sedimentation, recarbonation and finally filtration of a portion of the water through zeolite filters and the remainder through ordinary sand filters. The amount treated by the zeolite method would depend on the degree of hardness desired in the finished product.

In this way the advantages of both methods would be incorporated in one treatment plant. The advantage of the base exchange method of being able to effect any desired degree of softening would be retained without the inherent disadvantage of producing a high concentration of sodium salts in the treated water. The advisability of employing this method would depend, of course, on the proportion of temporary and permanent hardness in the water under consideration.

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MODERN PRACTICE IN CAST IRON PIPE MANUFACTURE[1]

By R. J. Disher[2]

Many years ago, when the specifications for vertically cast, cast iron pipe were compiled, there were conditions existing in foundry practice where additional weight and thickness were very desirable from the manufacturer's standpoint, and very acceptable at that time by the purchasers of cast iron pipe, as well as the water works association. The factor of safety in manufacture only was urgently needed to take care of irregularities then existent, but the factor safety in service was amply taken care of in the preceding specifications. When pig iron was selling at $7.00 to $8.00 per ton, Birmingham, labor was cheap, railroad rates were low and rebates freely given, a few pounds more per foot in the weight of cast iron pipe was considered of little importance either in the price per foot at the foundry or at the delivery destination, but with the cost of pig iron in recent years from $18.00 to $24.00 per ton, Birmingham, labor nearly double, railroad rates in same proportion, and being revised steadily upward, the necessity of a lighter pipe with the same or greater strength became an issue of importance.

The necessity of revising weights led to some very interesting developments. The logical method was that of casting horizontally, as a thinner pipe section can be cast in this manner than vertically. The older installations of cast iron pipe to which we all point with justifiable pride, as lasting a century or more, were cast horizontally, but in short lengths and of comparatively thinner wall section than the present vertical cast pipe of the same diameters.

Our present Birmingham Company started the pioneering in this stronger, tougher, lighter weight pipe field. Their aim was for a pipe of thin type, cast by natural methods, but with modern devices and materially changed foundry equipment. This has been fully justified by the results. Shortly after this method was found practical other mechanical processes were investigated. In less than a year,

[1] Presented before the Montana Section meeting, March 8, 1928.

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the rights to manufacture pipe by the centrifugal process in metal molds were purchased and one or two companies began to produce by that method. Later a group of other manufacturers, noting the success of these two processes, conducted exhaustive tests and experiments, with the result that another type of centrifugal pipe was developed, made by spinning in sand lined molds. At present there are three types of this stronger and lighter pipe recognized as standard. This is borne out by the fact that the major portion of cast iron pipe produced in 1927 was made by these processes. Other types of modern pipe are the centrifugal made in metal molds and the centrifugal made in sand lined molds, or known as sand spun.

The first type is made by spinning the molten iron against a water cooled special steel revolving cylindrical mold, the metal being introduced through a long trough extending the length of the mold and suspended to distribute the metal. The mold revolves at a high speed and recedes as the casting is formed. This type of pipe is made with plain spigot ends, as a bead would prevent the casting being pulled from the molds. As the casting is made against a water cooled metal mold, which chills and hardens the iron, it is necessary to put it through an annealing process to remove the strains and make it machinable.

With the other, or sand spun, process, sand lined cylindrical molds are used. The quantity of iron required to make a pipe is poured into the mold at one time, then the mold is revolved at a very high speed, throwing the metal with centrifugal force against the lined mold, thereby forming the pipe. There are certain other finishing processes on this type, which are necessary before the product is complete.

The horizontal sand cast process bears the name of the inventor of certain equipment, which has made the method a success and is generally known as the "McWane horizontal sand cast process." Pipe made by this method is made in moist or green sand molds with green sand cores. The flasks are placed in a horizontal position, the cores are set and with an ingenious device are adjusted to within $\frac{1}{1000}$ of an inch which holds them central when the metal is poured. The top half of the flask has several openings through which the metal is poured and the metal enters the mold itself through many gates. The ladle handling the molten iron has lips corresponding in position with the openings or risers in the flasks and when the ladle is tilted the metal pours into all openings simultaneously, and in this

manner the iron reaches all parts of the mold in the quickest time and under the highest temperature, as it has been proven that the hotter the iron is when it reaches its final destination in the mold, the stronger the casting will be. Special care is used in the selection of the sand and tests are daily made as to the qualities in the sand essential for accomplishing these purposes. Elaborate mixing and handling devices are used in connection with the sand and its tests. The moisture in the green sand molds and cores causes the crystals of the iron so to arrange themselves that the maximum strength without internal strains is obtained, leaving a soft, strong iron, easily machined. The casting is then left in the sand in which it was cast for a determined time, allowing the casting to cool gradually without strains which are incident to the other processes.

The horizontal method is very flexible, making it possible to produce pipe with various types of bells, spigots with plain ends or special beads, also with acceptable lettering or dates. While flexible, this method lends itself to standardization as the same internal and external diameters and the same weight per foot is used for pressures ranging from a few ounces of gas to 150 pounds water working pressure. With approximately the same external diameter as the old style pipe, the internal diameter is slightly larger, giving greater carrying capacity.

Actual test data show there is absolutely no relation between the thickness and longevity of cast iron pipe, as due to the granular structure, rust forms a protective coating and does not flake off as in the case of steel. Recent Federal Government tests made in the high acid soil of Southern California established that a thin cast iron pipe will last underground as long as a thick one; in fact, the balance is in favor of the thin section, due to its closer grain.

It may be well to mention in connection with the above, also, that the strength of a casting is not by any means in direct proportion to its thickness, which feature has been established for many years and is best presented by extract from article of Mr. Willard Rother of the Buffalo Foundry and Machine Company in the Iron Age, as far back as August 7, 1924, in which he states:

> The controlling factor governing the strength of cast iron is the presence of graphitic carbon, or carbon in the free state. It is well known that the proportion of free and combined carbon varies with the thickness of a casting. A thin casting cools quickly and allows a considerable portion of the carbon to remain in the combined state, which gives a closer grained iron. The same

iron poured in a heavier section cools much more slowly, permitting increasing quantities of carbon to change from the combined to the free state. In proportion to the time consumed in cooling, the metal naturally becomes coarser and weaker.

The foregoing statement confirms the contention that the thinner a cast iron pipe section is, the stronger it is in proportion to its thickness. In other words, nature penalizes you for increasing and rewards you for decreasing the thickness of a cast iron pipe section.

The green sand mold with the green sand core has been found to be the most natural way of utilizing this principle of cooling for an increase in strength, and the inner and outer surfaces are in contact with the same molding surface, sand. The dry sand mold and baked cores cool the iron too slowly, resulting in certain inherent weaknesses. The permanent mold cools the castings very rapidly, resulting in hardness, necessitating heat treating or annealing, and the sand spun process develops certain features requiring further finishing, none of which are encountered in the horizontal molding method.

The thickness of pipes manufactured under the above processes vary very slightly. Take for instance a 6 inch pipe manufactured by these three processes for 150 pounds working pressure. The variation in thickness between these pipes is only two hundredths of an inch, the average thickness being 0.36 of an inch, and a corresponding average weight of 25.5 pounds per running foot. The other sizes, of course, are in proportion. Compare this with Class B, which is, of course, heavier and thicker, but is only recommended for 86 pounds working pressure.

Up to about ten years ago, heavy cast iron pipe was considered entirely satisfactory from a manufacturer's and user's standpoint, but the economic situation having changed, naturally the investigations and developments mentioned were started. It may be said that progress in the development of better and stronger pipe has been in keeping with the modern progress in other lines of manufacture.

DISCUSSION

D. W. WALLACE:[3] The arguments for and against lighter weight cast iron pipe made by either A. W. W. A. method of manufacture, or more recent methods of horizontal casting, according to manu-

[3] American Cast Iron Pipe Company, Birmingham, Ala.

facturer's own standards (no reference here to centrifugal casting) only renews a situation existing in this country prior to the adoption of the A. W. W. A. standard specifications for the manufacture of cast iron pipe in 1908. Prior to this time pipe manufacturers had their own individual standards, more or less flexible, to meet all trade conditions. Competition with one another under such a situation made it difficult for any pipe buyer intelligently to analyze bids, and to choose the better pipe for the service intended. This dangerous situation resulted in the pipe buyer naturally putting a premium on pipe salesmanship, with little protection to the buyer.

The water works engineers and superintendents, all members of the A. W. W. A., organized for the good of the cause, realized the evils and dangers of the condition just outlined, compiled after much study, and adopted in 1908, what is known as A. W. W. A. Standard Specifications for the manufacture of Cast Iron Bell and Spigot Pipe. Such specifications govern in all respects the complete method of cast iron bell and spigot pipe manufacture, from pig iron to the finished product. Up to this time, the A. W. W. A. have not seen fit to change the specifications of 1908.

During the past war period of rapid development and expansion of cities, notably in Florida and the south generally, when the demand for pipe greatly exceeded the supply, a new pipe company begun the manufacture of a horizontal cast iron pipe, manufactured and marketed to the trade under the maker's own specifications. The horizontal cast method conflicts with the method laid down by the A. W. W. A. in many respects, notably: method of casting, kind of molds (wet or dry), wall thickness of pipe and likewise weights, etc., all of which are fundamental to A. W. W. A. specifications.

Few pipe buyers know the high factor of safety in A. W. W. A. specifications. As an illustration: 6 inch Class "B" pipe is rated for 86 pounds working pressure. The average bursting strength of 6 inch Class "B" pipe, taking all the manufacturers as a whole, is about 2000 pounds. It is, therefore, possible to make a pipe by any casting process 25 per cent or more lighter than Class "B" and guarantee it for several times in excess of Class "B" pipe rated pressure. However, when you tamper with wall thickness, you tamper with the all important item of factor of safety.

It is, therefore, suggested that in fairness to all the manufacturers of cast iron pipe, competition be invited on an equal basis of metal thickness and resultant weight per foot, due consideration being given

to the better physical characteristics obtained in some of the new products as a result of process of casting.

It is obviously unfair to the A. W. W. A. manufacturers for a municipality or pipe buyer to ask for and specify prices on Class "B" or "C" pipe, A. W. W. A. specifications with an alternate consideration from a single manufacturer's standard calling for pipe 25 per cent lighter in weight and expect the prices of the pipe 25 per cent heavier to be in line with the lighter pipe.

J. J. Wilson:[4] The speaker has called attention to, and emphasized the merits of, cast iron as a pipe material; and has suggested the use of a lighter weight cast iron pipe than that considered standard, or as approved by the specifications of the American Water Works Association. It is interesting to note that cast iron pipe manufacturers are suggesting and urging thin pipe, which approaches the thickness of steel pipe now on the market. I am reminded by contrast of the first cast iron pipes made in France, which, I understand, were about $2\frac{1}{2}$ inches in thickness, whereas the present specifications of a prominent manufacturer permits, for 4 inch class 50 pipe, a wall thickness of 0.26 inch, less permissible variation of 0.04 inch, or a minimum thickness of 0.22 inch, which is less than $\frac{1}{4}$ inch. This is less than 10 per cent of the thickness of the original pipe in France. Six inch pipe on the same basis has a minimum thickness of only one half a hundredth over $\frac{1}{4}$ inch. Class 150 has a thickness of 0.05 inch more; and Class 250 has a thickness of 0.09 inch more. These minimum thicknesses are only slightly more than half the thicknesses of standard Class B cast iron pipe as approved by the American Water Works Association.

Steel Pipe. If light wall pipe is desired, why not take advantage, as many have already done, of the strength and ductility of steel that is provided with a protective coating to prevent tuberculation inside and corrosion outside. Steel pipe can be furnished in longer lengths, which effects large savings in laying costs, and reduces the leakage factor and joint hazards. Every water works man knows that pipe joints are the greatest source of trouble. Hence by reducing the joints by one-third or more, these troubles are correspondingly lessened. With steel pipe there is practically no loss through breakage, whereas I have been informed that breakage of light weight cast iron is ordinarily reckoned at 2 per cent, or, if in rough country, at a larger figure.

[4] District Engineer, National Tube Company, Denver, Colo.

Steel pipe of various classes, such as welded and riveted has been used in water works since the beginning of its manufacture, nearly fifty years ago, but to shorten this discussion I will confine my talk to welded pipe such as manufactured by the National Tube Company.

Welded steel pipe for water works may be divided into four general classes: viz., (a) lead joint; (b) bolted joint; (c) screw joint, and (d) to a lesser extent welded joint.

Lead Joint Pipe, chiefly Matheson Joint, is a bell and spigot pipe well known throughout the Rocky Mountain States, where hundreds of installations have been made. The joint on this class of pipe has lately been modified to permit more caulking space, and at the same time furnish a better lock to the lead. Recent tests at our mill failed to blow out the lead before the pipe burst at 1800 pounds pressure per square inch.

As to protective coatings, I think you all realize, as we do, that they are necessary for all ferrous metals, and also for the non-ferrous metals, and even for concrete where buried in western alkaline soils. In Mr. K. H. Logan's paper on the "Soil Corrosion Investigation" of the United States Bureau of Standards, published by the American Institute of Mining and Metallurgical Engineers, the statement is made under "Results with Unprotected Pipe Materials" that "The soil rather than the type of material seems to control the corrosion so far as the ferrous metals are concerned, and as yet the corrosion rates of the wrought materials in any given soil do not markedly differ."

These tests included steel, wrought iron, armco iron and cast iron. It is interesting to note that the ordinary gray cast iron was the worst corroded in the strongly alkaline soils. While these tests are not conclusive as yet, they provide an intimation of what may be expected.

His report on bituminous coatings indicated that the heavier coatings were best, so that we have lately adopted these heavier dips and wrappings as standard for our water works pipe.

There are hundreds of installations of Matheson Joint Pipe throughout the West that are giving entire satisfaction and while there may be a few that have not fulfilled expectations, the same can be said of others and more costly materials. One of the larger installations is in the neighboring city of Butte, which has used either Converse or Matheson Joint Pipe for nearly forty years.

In the March, 1927 issue of The Journal there is a complete

description of the Butte Water Works. Among the conclusions, on page 386 is the following:

> The use of lap welded steel pipe, with joints installed in 1920 on Big Hole Line No. 2, has proven eminently satisfactory, both in first cost and in maintenance.
>
> The exclusive use of Matheson Joint welded steel pipe in our city system has proven eminently satisfactory not only in first cost, but in cost of maintenance. The fact that some of this pipe has been in continuous operation for forty years indicates long life for that class of material.

Other large cities using Matheson Joint Pipe almost exclusively are Ogden, Utah; Gary, Indiana; Albuquerque, New Mexico; numerous smaller cities use it exclusively; and hundreds are using it for flow lines, pressure lines or other parts of the water works.

Bolted Coupling Pipe, as well as *Welded Joint Pipe,* is chiefly used where pressures are too great for lead joint pipe. The pipe material, as well as the coatings, are practically identical with the Matheson Joint Pipe previously described. The bolted joint pipe is particularly desirable as the joints are easily and economically made up with unskilled labor, and may be made bottle tight without in any way disturbing the protective coating applied at the mill. This is important in reducing corrosion hazards near the joint, as the pipe can be kept dry on the outside in so far as leaking is concerned, and corrosion cannot proceed in the absence of moisture.

Screw Joint Pipe, known to everyone, need not be described except to call attention to the various finishes. For water pipe, it is usually galvanized by dipping in hot spelter, permitting the steel to take up as much zinc as it will naturally acquire; in this respect being quite different from wire and sheets which have much of the zinc removed while still hot. Much better than the galvanized pipe is the galvanized, dipped and wrapped pipe, which is used for permanent service connections in corrosive soils. Such pipe is used at Columbus, Albuquerque, and other places where the soil is highly alkaline. Such pipe is easily installed, strong and permanent. Of course, screw joint pipe is available in all ordinary sizes, and is generally used in water works practice up to three inches; but for larger sizes it is customary to use some of the other joints available.

Useful Life. The question is often raised, and very properly, regarding the comparative life of steel pipe as against cast iron or other materials. In considering this question one should take into consideration other factors such as coatings, soil conditions, fire

protection, capacity, reliability, etc., which may be summed up in the two words, "useful life." Mr. C. W. Sherman, of Metcalf and Eddy, in a paper before the New England Water Works Association in January, 1923, states: "In this country we have instances of cast iron pipe seventy-five years old and still in service; but the average age of the distributing system containing these pipes is likely to be less than twenty years because so large a proportion has been added in recent years." He gives the average life of a cast iron distribution system at fifty years. Various factors enter in determining "useful life." Among these, the growth of a city or town is important, as larger mains are often required within twenty years to meet such growth. The character of the water supply has an important bearing. Some waters cause interior corrosion or incrustation, which shorten the life of pipe. In southern New Mexico one town had to renew the cast iron pipe within twenty years because of corrosion stopping up the pipe on the interior and attacking the pipe on the exterior. Other towns are having similar troubles.

Many towns go to great expense to restore the carrying capacity of cast iron mains, only to find that corrosion with ensuing tuberculation starts again faster than before. Charlestown, S. C., and other places have turned to coated pipe as a result. Mr. E. Grimes, Supervisor of Waterworks of the Northern Pacific Railroad, Fargo, N. D. described the stoppage and cleaning of several such lines in Railways Magazine, page 427, 1924. A 10-inch pipe line, 3½ miles long, had incrusted to a depth of 2 inches, leaving a 6-inch opening with the result that pumps delivered 18,000 gallons per hour at 65 to 70 pounds per square inch pump pressure, whereas the original flow was 26,000 gallons at 45 pounds pump pressure. As most pipe lines are designed to provide for future increased demands, it is evident that a smaller pipe that does not deteriorate in carrying capacity with age is more desirable than large pipes that choke up. That this is more generally recognized by waterworks men, was brought out at a recent meeting of the A. W. W. A., at which W. W. Brush, of the City of New York argued that cast iron pipe should be coated to the same extent as steel pipe. That such protection should be required for western alkali soils is indicated by the experiences of many towns in Canada, Montana, Colorado and New Mexico, where unprotected cast iron has corroded to such an extent within twenty years that the pipes are greatly weakened and many leaks or broken pipes have resulted.

COST OF EXCAVATING WITH SMALL TRENCHING MACHINES[1]

By H. S. Greene[2]

About ten years ago public service corporations began to feel the need of a small ditching machine which would take over work at that time being done very expensively by hand. About five years ago this demand was met by two manufacturers who had not up to this time made ditching machinery. Both working independently produced machines of very different character. During the past five years, these machines have been universally applied in all parts of North America, Australia, Hawaii, and European countries, including Russia.

A small trench machine may be defined as a machine to cut about 24 inches wide and capable of digging 6 to 8 feet deep. This machine should be full crawler mounted and three point suspension and must be designed to travel fast from one part of a job to the other.

In suggesting the small trench machine, my prime consideration was the class of work which you might have to do. As a rule, large sewers and water mains are contracted. A small machine, however, may be used on all water main extensions, sewers, and house connections.

Trench machines of the continuous cutting type may be divided into three classes: the ladder, wheel, and vertical.

In the ladder type, the digging element consists of an inclined boom much like a ladder, this being pivotly secured to the frame of the machine. The upper end has the driving sprocket and the lower end the idler sprocket, and the chain to which the digging buckets are attached runs over these. The ladder type machine is generally used where ditches are 6 feet or over in depth.

The wheel type machine gets its name from the fact that the digging buckets are attached to a revolving wheel. Due to its design it is usually used for shallow trenches.

[1] Presented before the San Francisco Convention, June 13, 1928.

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The vertical boom type of machine probably needs more explanation as you may not all be familiar with the different features of its design. This machine was primarily designed to operate in close quarters and at the same time eliminate weight. In order to do this the digging element is mounted vertically. This feature of the design permits the buckets to be held positively to the work and at the same time they are arranged so that they can spring back under excessive strain. The machine is very short overall which is a big factor as it allows the machine to manoeuver quickly in close quarters. In fact, the machine can dig straight across the street. Vertical boom machines are now built to dig from 0 to 9 feet deep and from 4 to 24 inches wide.

Certain elements of design seem to be accepted by all of the manufacturers of small machines and will be found more or less constructively worked out. These items are:

The machine should be entirely supported on two crawlers and it should have a wide range of travel speeds, both for road and digging. The operator should be able to change instantly from one speed to the other to suit varying soil conditions.

One of the big problems that all trench machines face, and this applies also to steam shovels and drag line excavators, is the discharging of sticky materials from the buckets. All trench machines require a bucket cleaner or some method of discharging the sticky clay. In the ladder type the cleaner must be used almost all the time unless the digging is in a sand or gravel formation. The cleaner is made up of a cleaner plate which conforms to the shape of the buckets. This plate is mounted on a steel casting which is suspended on the headshaft. A ccil spring is used to hold the plate in position. As the buckets crowd against it the spring tends to compress and after the buckets pass, the recoil action tends to clean the plates. This cleaner is very satisfactory.

The wheel type machine uses a bucket with a removable back. In wet or sticky soil, this back is removed and the material is held in the buckets by means of gumbo fingers which might be likened to a pitchfork. Then what is called the sabre cleaner is added to the machine. This is a series of steel prongs spaced the same distance apart as the prongs on the buckets and as the wheel revolves these prongs pass through the buckets and strip out the dirt.

The vertical boom machine does not use a bucket cleaner as it is generally understood in relation to trench machinery. The buck-

ets themselves might be spoken of as being self-cleaning. The bucket line is built up of two principal parts, that is, the bucket link and the link above this which we might call the cleaner link. This link has a lip on the lower part of it which passes automatically through the buckets when they pass over the head sprocket. The resulting action secures a positive discharge of any material. There is nothing to put on or take off at any time, the parts are always ready and automatically go into action when they are required.

Another feature which should be incorporated in every machine is a safety device which will protect the machine from injury and eliminate the breakage of underground pipes. There are three methods of absorbing shock. First, using a belt drive between the engine and the machinery, second, a clutch which will slip underload, and, third, a safety device which will release under excessive load. The belt gives very satisfactory results. One manufacturer continues to use this between the engine and the machinery and without question this provides a safety factor as all shocks and strains from the digging teeth are absorbed in this belt. Another manufacturer uses a master clutch which is built into the driving machinery and is so designed that the pressure or power required to drive the machinery can be adjusted. The slipping clutch does not perform as satisfactory as the belt. A slipping clutch operates very much better when mounted on the head shaft. This type of a drive is adjustable and preferably this adjustment should be made at one point.

The manufacturers of the vertical boom ditcher have a patented overload release. This spring cushion is built into the driving sprocket and is mounted on the head shaft. This not only absorbs the shock, but when the teeth come in contact with large stones and other obstructions, in the trench, the springs compress and the driving machinery is released and the bucket line stops. The machine then can be stopped by means of the master clutch and in doing this the overload device immediately returns to a working position. If the operator does not step on the clutch the ditcher pulls again at the obstruction each half revolution of the head shaft and either loosens it or instantly releases. This action can be continued as long as the operator wishes to pick away at the obstruction. This safety device not only protects the machine, but also eliminates the breakage of pipes thich may be buried underground. The driving power of the device may be changed by increasing or

decreasing the tension on the springs and it is sometimes advisable to vary these due to different digging conditions.

The ideal ditcher should be designed so that it will leave a minimum amount of work to be done by hand when meeting obstructions. In city work this is frequently quite important. In a line parallel to the curbing, cross pipes may be encountered at regular intervals and there are also stones and cross-walks. The ditcher should be designed so that it will meet an obstruction without injury to the machine or without injury to a pipe, if it is encountered. The digging element must be arranged to rise over this obstruction and lower again to the proper depth, leaving the smallest possible amount of material to be excavated by hand. Many of the small machines today are used to dig house connections. Of course it is an advantage to be able to start close to the house and the machine should also have a very low bearing pressure per square inch of crawler surface.

The need of a small trench machine is much more apparent today than it was several years ago. Then all mains were placed in the roadway, but today many engineers are recommending that they be put in parkways or alleys. When this practice is followed the small machine is the answer for excavating the ditch. There is also another factor which influences us to consider the small machine and that is the shortage of common labor. A small trench machine will do the work of 30 to 50 men.

The small machine was originally designed for city conditions, but is able to give a very good account of itself on long distance cross country work where the machine is quite often operated twenty-four hours per day and where dependability is a matter of prime importance. Small ditchers today are digging oil and gas line trenches as rapidly and more cheaply than heavier ditchers.

THE COST OF TRENCH DIGGING

Having considered the general specifications of a small trench machine, we are prepared to analyze the cost of digging ditches. Results submitted by scores of users indicate a wide variety of methods in securing costs. For example, in the matter of depreciation, one contractor insists on writing off the whole cost of the ditcher on his first job. Occasionally a public utilities company will take the opposite extreme and figure a fifteen-year life. Perhaps an average of these two is a fair depreciation and may be taken as five years.

In the item, interest on the investment, there is not much variation. Four per cent of the purchase price extending over the life of the machine is close enough for practical purposes.

Repairs may be determined with some accuracy by examining records for previous years, but any estimate for the coming season is at the best merely a guess. It is possible, however, to determine some sort of an average from various reports which have been turned in by the owners of small machines. Expressed in a percentage of the purchase price, this can be used in estimating the cost of future work, assuming that no serious accidents will be encountered which will run the repairs beyond the average. This item should include the cost of all parts purchased, the cost of machine shop work, the cost of work by mechanic other than the operator, and even the cost of the operator's time when the work is done between jobs. This item should not include the operator's time for making ordinary adjustments or replacement of parts on the job because his time will be shown straight through as part of the operating expense. As nearly as can be estimated the repairs on a small machine, including the digging teeth, may be expected to run from 8 to 14 per cent of the purchase price.

An estimate based on a five-year life and 6 per cent interest on the investment, including repairs of say 12 per cent, will figure about $15.00 per day. This can be said to represent the overhead expense of operating a small machine. Daily operating expense, of course, may be determined quite exactly, using the operator's wages, plus gasoline and lubricating oil. In many conditions a helper will increase the amount of ditch dug per day sufficiently to pay his wages many times over. Gasoline consumed will vary from 1 to 2.5 gallons per hour and oil and grease might be said to be a dollar a day. This is very liberal and from these you will find that the total operating charge per day will be about $10.00 or possibly a little higher, if you use a helper. This makes the total cost for operating a small machine about $25.00 or possibly $30.00 per day.

In reducing these figures to a cost per foot basis, the most important item, of course, is the amount dug per day. This may vary through a very wide range. The amount of ditch dug per day may be limited by the laying of pipe, or the amount dug will also vary due to the material. For example, 400 feet in a caliche formation might be considered a good day's work, whereas 6000 feet a day of top soil is possible where the digging is easy and only 30 inches deep. Be-

decreasing the tension on the springs and it is sometimes advisable to vary these due to different digging conditions.

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tween these two extremes there is such a variety of widths, depths, and conditions of soil that an expert would have to be called in, if it was desired to have a fairly close estimate of cost in advance. Even then there may be a large discrepancy between the estimate and the actual cost due to the difficulty of determining the conditions underground.

After varying the different factors to meet your own conditions you may at the worst decide that it costs $35.00 per day to operate a small machine. Assuming that you cut only 500 feet per day the cost would be 7 cents per foot. After checking this up with actual cost records submitted by various water companies we find a fairly close relation.

One machine working in San Antonio cut a ditch at a cost of 5 cents per foot. This was in a particularly hard formation, which, even with cheap Mexican labor, hand work, cost 40 cents per foot.

A Houston ditch, 21 inches by $5\frac{1}{2}$ feet cost 7 cents per foot. Other examples follow:

Oakland, Cal.	18 inches by $3\frac{1}{2}$ feet cut for $4\frac{1}{2}$ cents per foot
Chicago, Ill.	18 inches by $4\frac{1}{2}$ feet cut for $4\frac{1}{2}$ cents per foot
Shreveport, La.	18 inches by $5\frac{1}{2}$ feet cut for $5\frac{1}{2}$ cents per foot

Norman, Okla., paid for a machine in cutting 34,000 feet. It charged 10 cents per foot for all work and the machine had paid for itself the second year. They also did work for the sewer department, gas company and telephone company.

The City of Thomasville, Ga., reports cost as low as $2\frac{3}{4}$ cents average for water and $4\frac{1}{2}$ cents per foot for sewer ditch.

Converting lineal foot cost to cost per cubic yard will no doubt interest you. Some of our records on cross country work show 5 cents per yard, but of course this is an extreme. Again records show costs as high as $1.16 per yard, but one might assume something was wrong here. After checking a large number of records and omitting from our summary those that were incomplete, the cost is about 25 cents per cubic yard of excavation.

RESULTS OBTAINED

Whether or not users, in figuring the probable cost of work in advance, follow the percentages and unit costs outlined above we do not know, but certainly reports which come to us indicate that in figuring the cost of jobs after completion of the work these users deviate quite markedly.

TABLE 1

Cost of excavating small ditches, machine versus hand methods

LOCATION AND NATURE OF SOIL	WIDTH OF TRENCH	DEPTH OF TRENCH	TOTAL JOB	TOTAL COST	TRENCH COST PER FOOT	HAND WORK COST PER FOOT	SAVING PER FOOT	TOTAL SAVING	REMARKS
	inches	*inches*	*feet*	*dollars*	*dollars*	*dollars*	*dollars*	*dollars*	
Streets, all kinds of soil	12	42	46,231		0.063				Average for three machines
Streets, all kinds of soil	12	42	176,076		0.065				Gas company
Streets, very rocky	18	44	35,047		0.081				Telephone
Streets, very rocky	16	48	18,570		0.051				
Streets and parkways, hard pan and clay	18	60	100,000		0.075				Water
Boulders, clay and sand	18	48	110,415		0.038				
Hard pan			39,000		0.072				Water
In parking, no hard dirt	18	42	9,110	463.09	0.05	0.22	0.17	1,169.51	
In parking, no hard dirt	18	48	356	28.34	0.08	0.23	0.15	53.03	
In parking, no hard dirt	18	60	325	20.14	0.06	0.32	0.26	84.22	
In parking, no hard dirt	18	66	200	18.89	0.09	0.38	0.29	57.92	
In parking, no hard dirt	18	38	1,553	109.52	0.07	0.26	0.19	290.04	
Surfaced street, loam	18	42	2,451	104.28	0.04	0.19	0.14	354.80	
Paved street, loam	18	36	104	8.68	0.04	0.16	0.13	13.37	
Unsurfaced, hard dirt	18	42	2,850	222.32	0.08	0.20	0.12	344.56	
Unsurfaced, hard dirt	18	48	424	25.14	0.06	0.19	0.13	57.04	
Surfaced, hard dirt	18	42	1,229	139.11	0.11	0.19	0.08	99.69	
Surfaced, hard dirt	18	48	233	29.86	0.13	0.32	0.19	45.32	
Surfaced, hard dirt	18	60	100	14.55	0.15	0.34	0.19	19.36	

Surfaced, hard dirt	18	42	4,261	459.32	0.10	0.27	0.17	665.27
Paved street, hard dirt	18	36	195	19.71	0.10	0.19	0.09	18.06
Surfaced, rocky soil	18	42	693	64.01	0.09	0.33	0.24	160.99
Surfaced, hard dirt	18	42	209	24.66	0.12	0.32	0.20	43.20
Resurfaced, rocky soil	18	42	700	57.20	0.08	0.32	0.24	169.88
Paved street, hard dirt	18	48	363	28.94	0.08	0.22	0.14	49.47
Paved street, hard dirt	18	42	424	37.83	0.09	0.32	0.23	99.81
In parking, no lawn, rocky soil	18	42	164	12.70	0.08	0.32	0.24	40.49
In parking, in lawn, rocky soil	18	48	397	31.06	0.08	0.19	0.11	44.03
In parking, in lawn, rocky soil	18	42	300	20.21	0.07	0.22	0.15	44.73
In parking, in lawn, hard dirt	18	48	231	22.35	0.09	0.21	0.12	27.20

In the matter of interest, we find that users are quite likely to figure 6, 7, or 8 per cent of the total purchase price, at least for the first year, instead of taking an average over the life of the machine and figuring 4 per cent on the purchase price.

The total overhead as reported to us by the various customers shows very little variation, running from \$10.30 to \$12.20 per day, with the exception of one user who has placed a heavy depreciation against a seventy-day job. This makes the overhead total \$19.16 per day.

Under the heading of operating expense, results of four users agree very closely, varying from \$7.16 to \$8.09 per day. Two other users show \$12.65 and \$12.91 per day. In one of these cases we know that the high rate is due to the fact that the operator and helper have been permitted to remain idle when the machine was not digging or, in case they were put on other work, their pay was still charged against the ditching job. Figures that we have indicate that on city work the ditchers are idle about one-third of the time waiting for the pipe-laying gang to catch up with it or for other reasons not traceable to the machine. Some users state that under such conditions the operator and helper have definite jobs to which they return until the machine is again needed.

In one case the operating expense is shown as \$20.80, which may be due partly to charging idle time of the operator and helper against the machine and is also due to a rather excessive moving charge which we take to be the time of a truck and trailer moving the ditcher from one job to another.

In spite of these few discrepancies in the method of figuring costs, it happens that, in two of the three cases, the jobs showing the largest charges per day also show the largest average distance dug per day so that the costs per foot of trench are not far out of line. In fact, the job which shows \$12.65 per day operating expense shows the lowest cost per foot, namely 3.8 cents. The costs vary from this figure to 8.1 cents. This is a job averaging only 3 feet 8 inches deep, but the digging is described as very hard.

A tabulation of costs is appended in table 1. While most companies are willing to discuss matters of this kind with individuals they are not willing to have their figures broadcast. Therefore in this tabulation we give only key numbers, but the Barber-Greene Company will be glad to furnish names on request.

ELECTROLYTIC CORROSION PREVENTION OF CONDENSER TUBE CORROSIVES[1]

By F. G. Philo[2]

The subsequent explanations of the theory of corrosions are mainly obtained from the works of Frank N. Speller, "Corrosion, Causes and Prevention," and Ulick R. Evans, "The Corrosion of Metals."

Corrosion may be broadly defined as the chemical action of certain external agencies on metals, which causes their deterioration or destruction. Thus metal tends to convert to more stable combinations of which metal ores are familiar examples.

THE ELECTROCHEMICAL THEORY OF CORROSION

This theory is now generally accepted as the one which best explains the facts that are established about corrosion. All metals, when placed in contact with a solution, have a definite, inherent tendency to go into solution. The element can enter solution only by displacing some other element already in solution. For instance, a piece of iron placed in a copper sulphate solution will dissolve, but at the same time copper is plated out and appears on the surface of the iron. In the ordinary case of most metals immersed in water, hydrogen is the element plated out. The hydrogen gathers on the surface of the metal in the form of a thin invisible film. The presence of this film tends to obstruct the progress of reaction by insulating the metal from the solution. Thus the first stage of corrosion may come to a stop before any visible damage can be done. In order that the corrosion may proceed, the film of hydrogen must be removed. This can happen in two ways—either it may be combined with oxygen in solution to form water, or the hydrogen may escape as gaseous hydrogen. Dissolved oxygen is usually present in water solution. The process of corrosion is therefore free to continue, if

[1] Presented before the Boiler Feed Water Committee Sessions, San Francisco Convention, June 12, 1928.

[2] Superintendent, Steam Generation Department, Southern California Edison Company, Los Angeles, Calif.

nothing else interferes, with the rate at which this oxygen combines with the hydrogen to form water. In acids the same reaction takes place, and in addition the tendency for hydrogen to plate out is much greater. The corrosion is therefore generally more active in acid solutions.

Dissimilar metals in contact with each other or with electrically conductive material in solution, tend to accelerate corrosion. This action is indicated by an electric current which flows through the solution from the more corrodible to the less corrodible material. The more corrodible metal is the anode. The less corrodible metal is the cathode. The current flows in the liquid from the anode to the cathode and is returned through the metal contacts to the anode (figure 1). The anode is corroded. Hydrogen gas is evolved at the cathode. This combination is really a galvanic battery, producing current by dissolution of the metal at the anode.

CLASSIFICATION OF PRIMARY FACTORS TENDING TO CORROSION

Mr. Frank N. Speller has classified the primary factors which indicate the tendency of corrosion to proceed, as follows:

1. As applying to anodic reaction, or to reactions which occur only at the anode.

a. The normal potential of the metal or solution pressure.

b. The concentration of metal ions in contact with the metal surface.

2. As applying to cathodic reactions, or reactions which occur only at the cathode.

a. The hydrogen ion concentration of the solution in contact with the metal.

b. The normal potential of hydrogen.

1. *a*. The normal solution pressure of the metal is an inherent quality which indicates its tendency to dissolve with the formation of ions, or electrically charged atoms. It depends, of course, upon the solution in which the metal is immersed. This solution pressure may be found by determining the opposite electric potential which will prevent the metal from going into solution. The pressures have been determined for all elements in a standard solution, and tabulated in a series according to the potential values. This series, which is called the electrochemical series, gives an indication of which metal of a bimetallic combination will corrode. Corrosion will

occur at the metal with the lowest solution pressure. Some of the more common elements may be listed in the order of decreasing solution pressure, as follows: gold, silver, copper, hydrogen, iron (ferric), tin, lead, nickel, iron (ferrous), zinc. Thus, in an iron and copper cell, the iron will corrode (anodic) and the copper will be cathode with evolution of gas. But by application of external current, as from a storage battery, these normal solution potentials

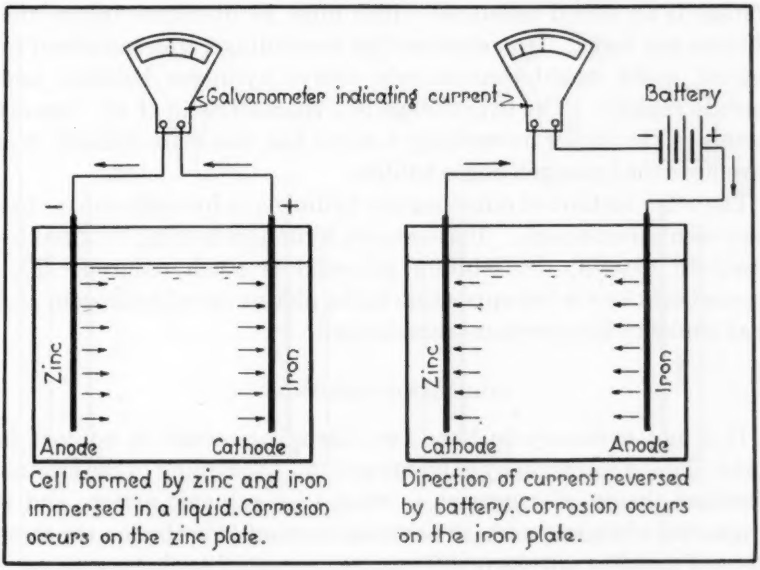

FIG. 1. CORROSION OF DISSIMILAR METALS IMMERSED IN A LIQUID

can easily be overshadowed, and the reaction speeded up or driven in the opposite direction (figure 1).

b. The concentration of metal ions in the solution. The corroding metal sends metal ions into the solution, and these ions tend to decrease the rate of corrosion by developing a back pressure, lowering the effective solution potential.

2. a. The hydrogen ion concentration (acidity) of the solution in contact with the metal surface. The pressure of hydrogen ions in high concentration makes the disposition of atomic hydrogen easy. The tendency for corrosion increases therefore with the hydrogen

ion concentration at the cathode. This is the opposite of the effect of metal ion concentration at the anode, as noted above.

b. The normal potential of hydrogen. When brought in contact with a solution, gaseous hydrogen exerts a solution pressure like that of a metal. This pressure opposes the plating out of hydrogen, or, in other words, opposes the continuance of corrosion.

When hydrogen is present as a gas with bubbles being evolved during corrosion overvoltage is an important factor. This overvoltage is an added resistance which must be overcome before the bubbles can form. If it were not for overvoltage, iron immersed in neutral water would continuously evolve hydrogen bubbles, and corrode rapidly. The overvoltage is a characteristic of the various metals. The higher overvoltage a metal has, the more difficult it is to remove the hydrogen as gas bubbles.

The other method of removing the hydrogen is by oxidation, as has been mentioned before. If the atomic hydrogen is being oxidized by dissolved oxygen, the solution potential is much reduced. This means that there is less opposition to the plating out of hydrogen, and that tendency for corrosion is accelerated.

LOCALIZED CORROSION

It is not necessary to have two dissimilar metals in contact in order to have corrosion by galvanic action. According to the electrochemical theory all corrosion is caused by galvanic action, and is originated when two parts in electrical contact (whether on the same piece of metal or not) have difference in potential so that a current is started. As long as corrosion lasts, this current is maintained by the corroding part going into solution. The process may be accelerated or reversed by current from outside source.

Localized corrosion may be brought about by solution of different substances (acids, bases, salts, or gases) in contact with adjoining parts of the same metallic surface, or by two solutions of a single substance which vary in concentration. When a metal is in contact with two solutions of the same salt but of different concentrations, a current flows from the metal in contact with the more dilute solution through the solution to the metal in contact with the more concentrated solution. In other words, the metal in contact with the more dilute solution is anodic and will corrode.

DIFFERENTIAL AERATION

The effect of varying concentration of dissolved oxygen in contact with the metal surface has been studied by many investigators, particularly Evans.

If a metal rod is submerged vertically in a solution, the part just under the water will be cathodic, and the end at the bottom will be anodic and corrode. This is explained by differential aeration. The part which is least exposed to air will corrode. Similarly rust and other substances, which shield the underlying areas from contact with oxygen, render these areas anodic with respect to the surrounding surface and accelerates a corrosion already started. If a surface has become pitted from corrosion, the tendency is therefore for these pits to increase. Firstly, because the bottom of the cavity is covered by a solution of a different concentration from that of the surrounding metal surface, and secondly, on account of differential aeration. The former may tend to deepen the pit or create another, the latter will deepen the pit which already exists.

EFFECT OF STIRRING—TURBULENT FLOW

Agitation affects the localization differently, depending upon the amount of oxygen in the solution. Portions of the metal surface in contact with solution in motion tends to make the area anodic. Presence of oxygen (as mentioned above) tends to make the surface cathodic. Whichever influence is the strongest will have the most effect. On iron, the presence of oxygen will predominate, and stirring will not materially change the potential, but on copper, and copper alloys, the effect of motion is stronger than the effect of differential deaeration. Copper is a more "noble" metal, and is more influenced by the metal ion concentration in the quiet liquid film at its surface than the more soluble iron. The metal ions are removed by stirring and the back pressure decreased which will increase corrosion. High velocity and turbulent flow (which also causes differential aeration) are therefore very harmful to copper and copper alloys.

SOLUBILITY OF OXYGEN IN WATER

The rate at which oxygen dissolves in water from the air is influenced mainly by the oxygen solubility, the degree of saturation of the solution, and the agitation of the water surface. As oxygen is

more soluble than other gases in the air, it will amount to 35 per cent by volume of the dissolved gases from the air, as against 21 per cent of the gases in the air. The rate of oxygen solution in the water depends on the actual concentration of the solution. It will be greatest when there is no oxygen in the solution, and zero when the solution is saturated.

CORROSION IN ABSENCE OF OXYGEN

There are cases where corrosion takes place, with evolution of hydrogen, in the absence of oxygen, even in neutral or slightly alkaline waters. Pure iron corrodes very slowly in the absence of oxygen, while the rate is much greater with impure iron, such as cast iron. The graphite in cast iron forms cathodes from which hydrogen gas can escape (due to low overvoltage of graphite) in the absence of oxygen. Corrosion can take place in the absence of oxygen only by evolution of hydrogen bubbles.

PROTECTIVE FILMS

In general, where the anodic reaction leads to the formation of soluble salts of the anode metal, there is nothing which will interfere seriously with the corrosion.

If the corrosion product on the anodic surface is an insoluble salt, this cover may act as a protective film, and considerably retard corrosion. This film may, on some metals, be only a few molecules thick, invisible to the microscope.

In order to be protective the film must also be adherent and continuous. It must not be porous and have no cracks. Copper oxide, for instance, occupies a larger volume than copper, and forms an effective protection. The corrosion decreases as the oxide film increases. While protective films thus may greatly influence the rate of corrosion, they do not affect the tendency to corrode as explained by the electro-chemical theory..

ALLOYS USED FOR CONDENSER TUBES

Condenser tubes are usually made of 70 per cent copper and 30 per cent zinc. This alloy, when annealed, is homogeneous. For some purposes a brass containing 60 per cent copper and 40 per cent zinc is employed. This is Muntz metal, generally used in fresh water. For the purpose of making the corrosion product more adherent, and therefore more protective, 1 per cent tin or 2 per cent lead is added

to these alloys. The Admirality brass, commonly used with ocean water, has 70 per cent copper, 29 per cent zinc and 1 per cent tin. An alloy which has given good results in England, has 62 per cent copper and 38 per cent zinc.

CLASSIFICATION OF CONDENSER TUBE FAILURES

With some knowledge of the fundamental causes of corrosion as explained by the electro-chemical theory, a classification of the more common causes of condenser tube failures may be made, as follows:

1. Dezincification. Dezincification is an anodic attack on brass, whereby both the copper and zinc pass into solution and the copper is redeposited. This is fairly well proven by the fact that the potential required to cause anodic attack is similar to that needed for attack on copper, and brass contains 70 per cent copper. If dezincification had consisted in removal of zinc alone, a potential requirement near that of pure zinc would be expected.

a. Dezincification of the localized type. It is characterized by specks of white or greenish substance, which is mainly zinc oxychloride. Red areas of spongy copper are found under these specks, and the porous formation may extend clear through the thickness of the tube and form a "plug." This type of corrosion appears to be favored by the presence of foreign bodies, such as shells or coke. It is considered in most cases to be due to production of currents set up between the unchanged brass and the copper of the corrosion product. The corrosion may be started by any of the several causes of difference in potential, such as difference in concentration of salt deposits, differential aeration, etc. If the corrosion product is compact, it will shield the brass from deep seated attack. The reason for the superiority of brasses containing lead or tin is thought to depend on the fact that they give an insoluble corrosion product filling up the pores of the porous copper.

b. Dezincification of the layer type. This is characterized by the formation of a layer of copper over the surface of the tube. The solution of brass and subsequent redeposition of metallic copper is thought to be favored by acid in the water, by action of electric currents, and by high temperatures.

2. Deposit attack. This type is localized and therefore serious. It is connected with deposit in the tube of any foreign material, such as shell, coke, seaweed or sand, and is usually produced in places, where the foreign material settles down. It is most common at the

inlet end and bottom half of the tube. The corrosion is the result of electrolysis under the influence of local current. The E.M.F. depends on the difference in potential between the surrounding metal and the metal covered with the deposit. It might also be that certain corrosion products, which would otherwise be swept away by the waterflow, are entrapped by the foreign body and stimulate further corrosion. In any case, a local current is set up.

3. Water line attack. This acts similar to the deposit attack, but is confined to the inlet end of the tubes and caused by air in the water. The air bubbles are believed to cling to the walls, or a permanent air space may exist at the inlet end of the tubes.

4. Differential aeration—wet and dry patches. It is very likely that corrosion often starts when the condenser is drained, in the presence of dirt in the tube. When the condenser is drained, and the water stagnant, in the tubes, the foreign matter may settle on the bottom and cause differential aeration cells, the unaerated electrode being the anode. Copper salts are produced at the bottom of the stagnant pools. When the condenser again is filled, the copper salts may interact with the unchanged brass, yielding metallic copper. If this copper is porous it will act as cathode to the unaerated brass underneath and the corrosion will continue.

5. General thinning. All tubes become gradually thinner with use. In most cases, this is not serious. However, in strongly acid or ammoniacal waters the rate has been known to be rapid.

PREVENTION OF CORROSION IN CONDENSER TUBES

It is probable that the designer of a condenser can do as much to prevent corrosion, as either the operator or the manufacturer. Every endeavor should be made to produce uniformity of flow over all points on the tube surface. The non-uniform flow which occurs through the tubes causes trouble in several ways. Currents are set up due to cells of the unequal velocity type. It might remove protective scale in one place and leave it in another, again setting up local current. It might cause air bubbles to impinge on the surface.

Properly designed waterbox and gradual change of flow at tube inlets are of value in this respect. Also low condenser tube velocities.

The manufacturer can contribute by making a uniform, close grained alloy, properly annealed. If the brass is not uniform, local corrosive currents are certain to appear. A protective scale on the interior of the tube surface may be put on before the tubes enter

service. It is thought that pickling in seawater before installation might be of value to create a protective film.

The operator can also do a great deal to prolong the life of his tubes.

Frequent cleaning of tubes to prevent accumulation of foreign bodies are of great importance.

The modern electro-chemical system for protection of the condensers is largely the work of Cumberland. The tubes are made cathodes of an electrolytic cell by being connected to the negative pole of a generator having a suitable E.M.F. (6 to 10 volts generally sufficient). The anodes are blocks of cast iron placed in the waterbox and carefully insulated from it. When current is flowing, the surface of each of the tubes is cathodic, the object being to prevent the passage of copper and zinc from the metallic to the ionic condition. This protective system appears to be distinctly helpful as long as corrosion has not started when the system is installed. It will not put a stop to corrosion which has already started, nor will it prevent formation of corrosion due to deposit attack, waterline attack, eddy-currents, turbulent flow, differential aeration or other common causes of condenser tube corrosion. Whether it is possible to design a protective system efficient enough to exclude local corrosion entirely is not known.

The main value of the system lies in the fact that it prevents attack from outside stray currents, which is a very common source of trouble in ships and central power stations. Installation of an electrolytic protective system does not, as a rule, prevent the effects of poor design or careless operation.

Electrolytic protection is more efficient in short than in long condensers, where difficulty is had in obtaining sufficient current density in the center of the tubes. In general, the current density should be 2.5 to 5 amperes per 1000 square feet of cooling surface.

CORROSION PROBLEMS OF CONDENSERS IN LONG BEACH STEAM PLANT NO. 2

General description of condensers

The Long Beach Steam Plant No. 2 has three turbo-generators which are numbered Nos. 7, 8 and 9 respectively. Nos. 7 and 8 units are alike. They have a rated capacity of 35,000 kw. each, with a 55,000 square feet two-pass condenser of 10,504 tubes, 5,252 tubes

in each pass. The tubes are 20 feet 3 inches long, 1 inch outside diameter, No. 16 B.W.G. The active tube length inside the tube

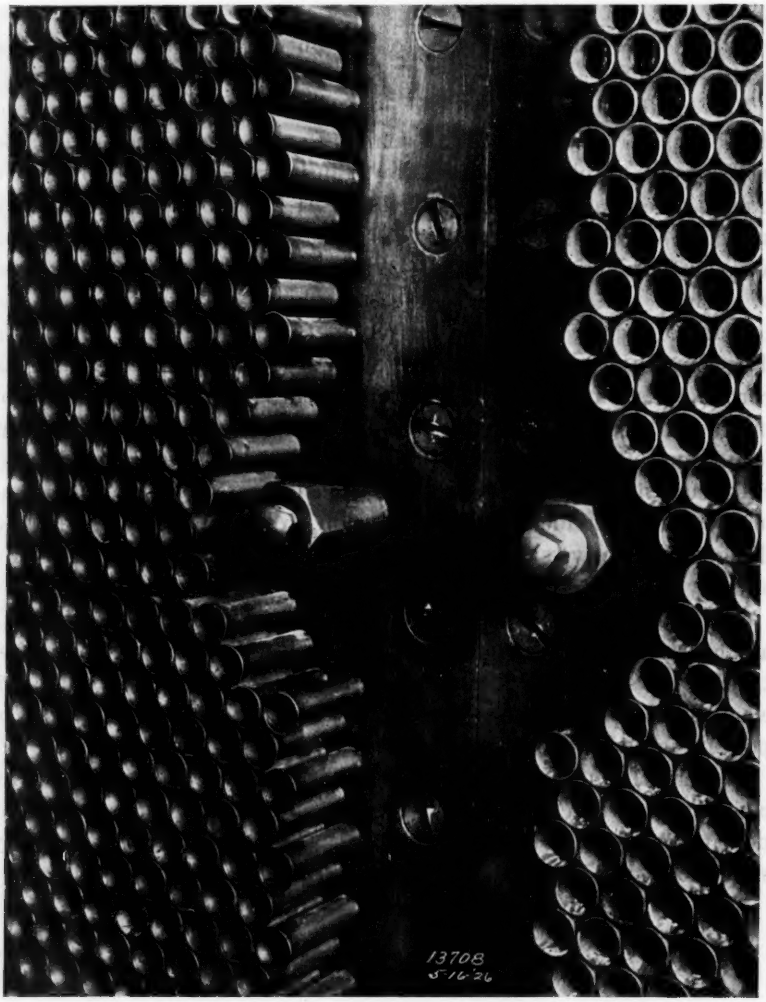

FIG. 2. INLET END OF TUBES NO. 9 CONDENSER

sheets is 20 feet. The tubes are packed in each end with metallic packing, having a fibre ring on each side, and held in place by ferrules.

No. 9 unit has a rated capacity of 52,800 kw. with a 75,000 square feet two-pass condenser of 14,300 tubes; 7,068 tubes in the first pass and 7,232 tubes in the second. The tubes are 20 feet 7 inches long, 1 inch outside diameter, No. 16 B.W.G. They are rolled in the inlet end and packed in the outlet end with metallic packing and ferrules, similar to the tubes in Nos. 7 and 8 condensers. The inlet end is belled, as shown in figure 2, and projects 4½ inches outside the tube sheet. This is done to prevent condenser leakage in case the inlet end should be attacked by corrosion. The active length between the tube sheets is 20 feet.

FIG. 3. PHOTOMICROGRAPH OF ADMIRALTY BRASS

All three condensers were manufactured by the Westinghouse Electric and Manufacturing Company, and are of the radial flow type. The steam enters the tube bundle radially and flows toward the center, where the air and uncondensed vapors are removed.

Corrosion in Nos. 7 and 8 condensers

As these condensers are alike, and have developed similar cases of corrosion, they are treated together in the following paragraphs:

The tubes of Nos. 7 and 8 condensers are manufactured by the

Scovill Manufacturing Company of admirality brass. A sample from No. 7 condenser had the following analysis: copper, 71.5 per cent, zinc, 27.1 per cent and tin, 1.4 per cent. A photomicrograph of admirality brass is shown in figure 3. The brass has been etched with ammonium peroxide and shows an average grain size of 0.032 mm.

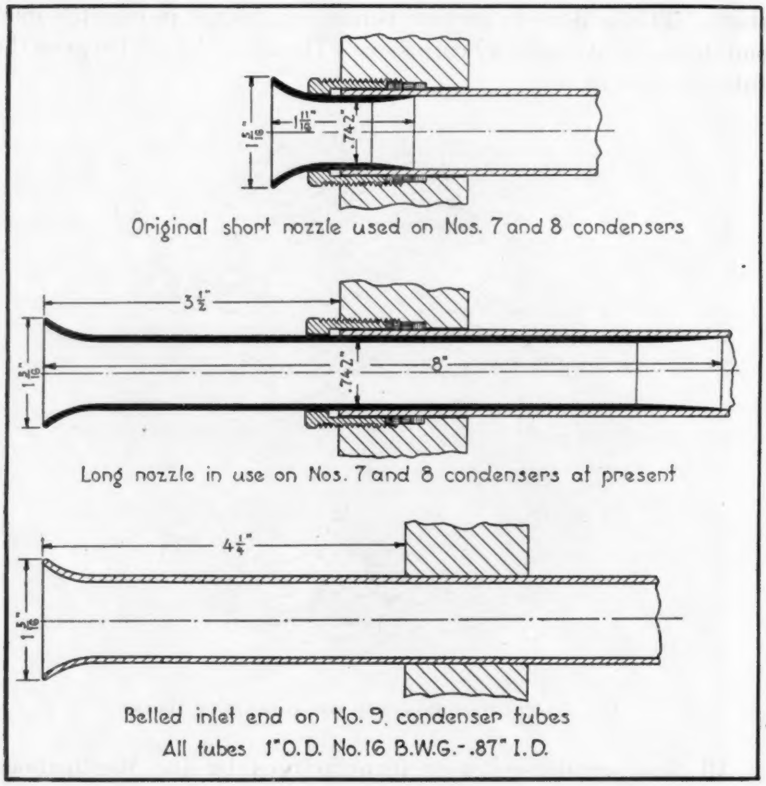

FIG. 4. INLET ENDS OF CONDENSER TUBES

The condensers were originally built with a short entrance nozzle inserted in the inlet end of each tube. This nozzle, which is shown in figure 4, fits inside the condenser tube and has a belled inlet end to reduce the entrance losses. The downstream end of the nozzle is bevelled off to a sharp edge, giving a smooth change of flow to the tube. The nozzle is of brass.

No. 7 unit was placed in operation November, 1924, and No. 8 unit on January, 1925. Very soon tube leaks began to develop in both condensers. In the first six months a total of ten tubes were plugged in No. 7 condenser, and two in No. 8 condenser. The leaks were not confined to any particular spot, but most of them occurred in the first pass. On inspection it was found that the downstream edges of the entrance nozzles had been distorted by driving the nozzles in place. The burred edges created eddy currents, which

FIG. 5. INLET OF TUBE FROM NO. 7 CONDENSER, ROW 99 FROM TOP, TUBE 11 FROM "KEYSTONE" EAST BOTTOM. REMOVED MARCH 7, 1928. SANDBLASTED

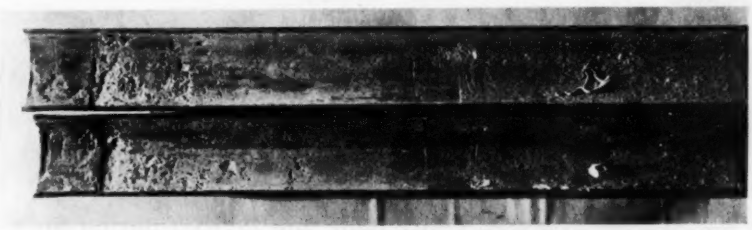

FIG. 6. INLET END OF TUBE FROM NO. 7 CONDENSER, ROW 97 FROM TOP, TUBE 24 FROM WEST, WEST BOTTOM. PLUGGED FOR LEAKS MARCH 20, 1928. REMOVED FOR INSPECTION MARCH 31, 1928

were instrumental in pitting the tubes. These pits may be seen on photographs, figures 5 and 6, from tubes, which were removed later. They start about 1 inch from the inlet end. All entrance nozzles were pulled out after about six months service, in the summer of 1925, and replaced by longer ones in March and April, 1926. The long nozzle, known by the trade name "Flowrite" is shown in figure 4. It has the same diameter as the short ones, but is 8 inches long, and was inserted $4\frac{1}{2}$ inches into the tubes, sufficient to cover the pits

started by the short nozzles. The downstream edge was rolled tight against the tube walls, preventing any danger of eddy currents and of continued corrosion of the pits started by the short nozzles. The long nozzles stand up well, and the corrosion at the downstream edge is slight. Referring again to figures 5 and 6, the extent of protection afforded by the long nozzle may be observed. Figure 5 is a sand-blasted tube, and figure 6 is a tube which had been plugged up by a shell, so that marine growth had started in the tube. Both tubes were removed in March, 1928. They have had short nozzles

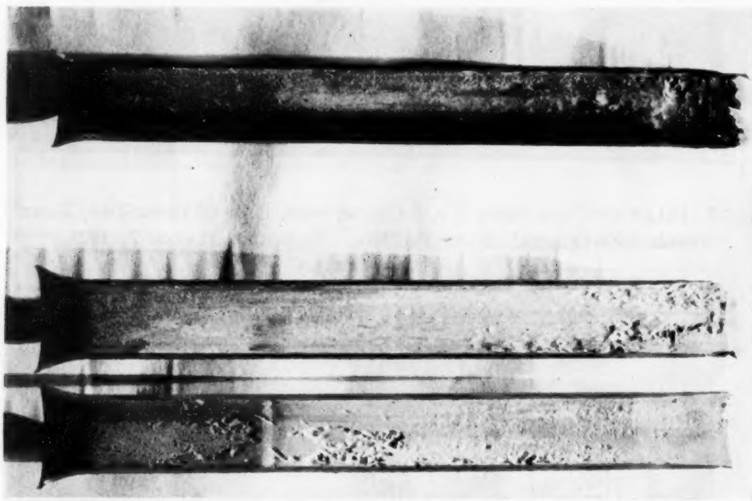

FIG. 7. WORN FLOWRITE NOZZLE, FROM ROW 75, EAST BOTTOM NO. 8 CONDENSER. INSTALLED SEPTEMBER, 1926. REMOVED NOVEMBER 1, 1927

in service for six months and long nozzles in service for two years. Both tubes are from the first pass No. 7 condenser.

The downstream nozzle edges wear out after about six months service in the first pass and ten to twelve months in the second pass. The worn nozzles are then cut $\frac{1}{4}$ inch shorter, a new edge reamed, and the nozzles reinserted $\frac{1}{2}$ inch further into the tube. At that rate the average life of a nozzle should be three to four years. A picture of worn flowrite nozzle edges is given in figure 7. Another picture of nozzle corrosion is given in figure 8. The bottom part is shown and the corrosion is probably formed by differential aeration in stagnant

water after the condenser has been drained. Although this sample shows an extreme condition, by no means typical, it gives a good indication of what frequent draining and idle periods will do. If a condenser is going to be idle for an extended period it is good practice

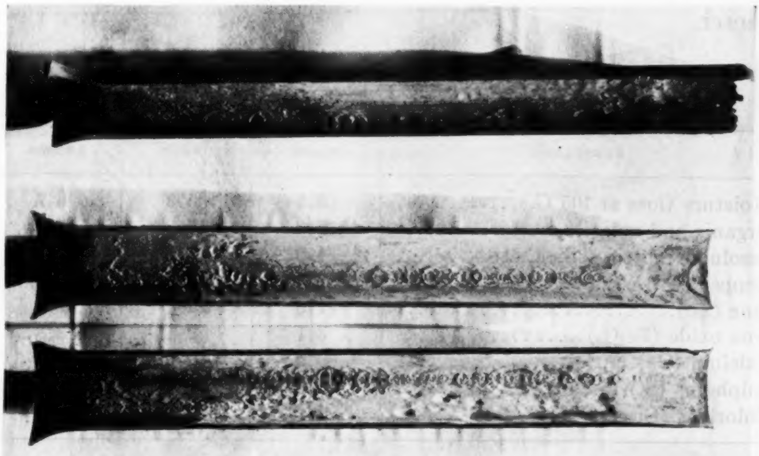

FIG. 8. FLOWRITE NOZZLE CORROSION, FROM ROW 75, EAST BOTTOM NO. 8 CONDENSER. NOZZLE INSTALLED SEPTEMBER, 1926. REMOVED NOVEMBER 1, 1927

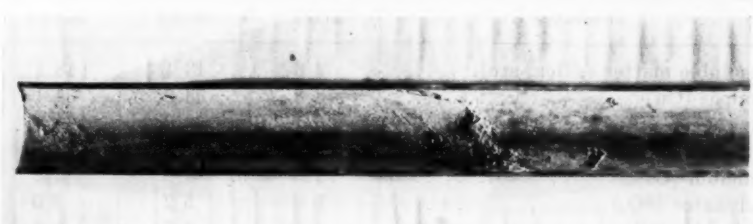

FIG. 9. TUBE LEAK FROM SAME TUBE AS SHOWN IN FIGURE 5

to clean out all deposits and use fresh water in doing so. This will greatly reduce the danger of differential aeration and of corrosive current due to wet and dry patches with different concentration of salt deposits.

After the removal of the short nozzles, and before the long ones

were installed, No. 7 condenser had three leaks, and No. 8 one tbeu leak in 1925. In 1926 the two condensers had two and one leak, respectively; in 1927 No. 8 had one leak, and in 1928 No. 7 has had five leaks to date. The total number of tube leaks over three and one-half years service is 20 in No. 7 condenser and 5 in No. 8 condenser.

TABLE 1

Chemical analysis of tube deposits—results in per cent

SUBSTANCE	BLACK	GREEN	BROWN
Moisture (loss at 105°C.)	5.1	5.3	6.7
Organic and volatile matter	12.3	19.0	25.3
Insoluble matter (silica, etc.)	1.9	8.1	11.7
Copper (Cu)	52.8	20.9	22.0
Zinc (Zn)	11.6	24.0	7.6
Iron oxide (Fe_2O_3)	3.1	2.1	13.8
Calcium (Ca)	0.9	0.6	1.4
Sulphates (SO_4)	0.4	3.2	2.3
Chlorides (Cl)	1.3	2.8	5.7

TABLE 2

Chemical analysis of tube deposits. Dry basis. Exclusive of inorganic and volatile matter

Results in per cent

SUBSTANCE	BLACK	GREEN	BROWN
Insoluble matter (silica, etc)	2.6	13.1	18.1
Copper (Cu)	73.3	33.9	34.1
Zinc (Zn)	16.1	38.9	11.8
Iron oxide (Fe_2O_3)	4.3	3.4	21.4
Calcium (Ca)	1.3	1.0	2.2
Sulphates (SO_4)	0.6	5.2	3.6
Chlorides (Cl)	1.80	4.5	8.8
	100.0	100.0	100.0

The last tube leak found in No. 7 condenser is shown in figure 9 from the same tube pictured in figure 6. It is a typical result of "deposit attack." This tube had been plugged by shells, and pitting occurred under several of these shells. The corrosion is caused by a local current formed by difference in potential between the metal covered by the shell and the surrounding metal.

Tube deposits

The deposits on the inside and outside of the tubes have been measured and analyzed. The inside of the tube is covered by a green, hard scale, over this scale is a deposit of brown coating, much

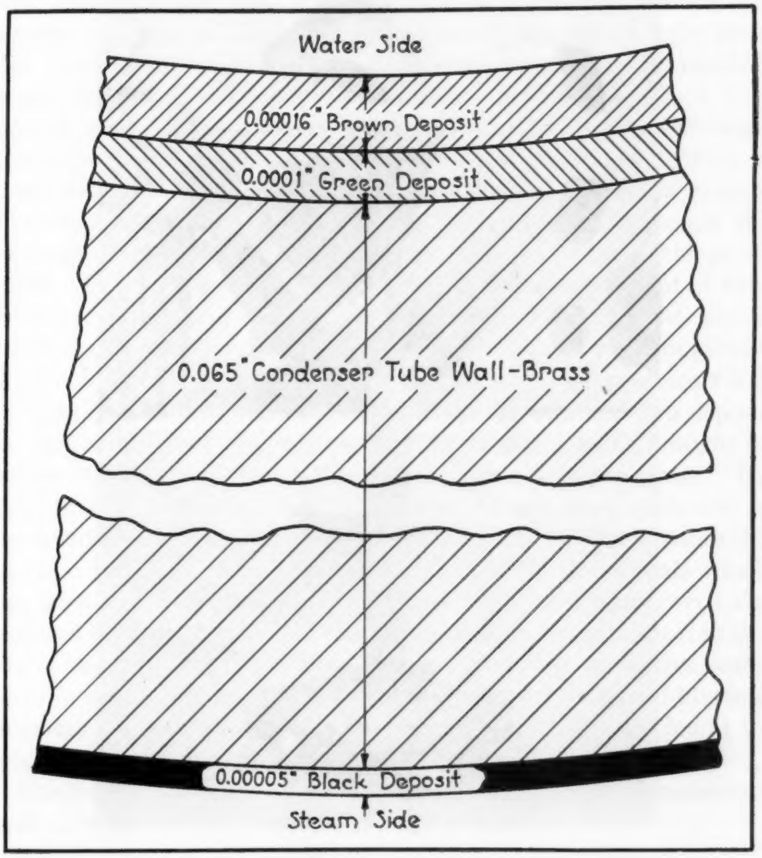

FIG. 10. DEPOSITS ON CONDENSER TUBES

softer, which is slimy when wet and brittle when dry. The outside of the tubes have black covering, that looks and feels like soot. Chemical analysis of these deposits are given in table 1.

The green scale is a mixture of hydroxides, oxy-chlorides and basic carbonates of copper and zinc, together with some calcium sulphate

and oxide or hydroxide of iron, silica and organic matter. The brown deposit is very similar to the green deposit, except for the large percentage of iron (ferric hydroxide from the electrolytic protective system) which gives it a brown color. The black deposit on the tube

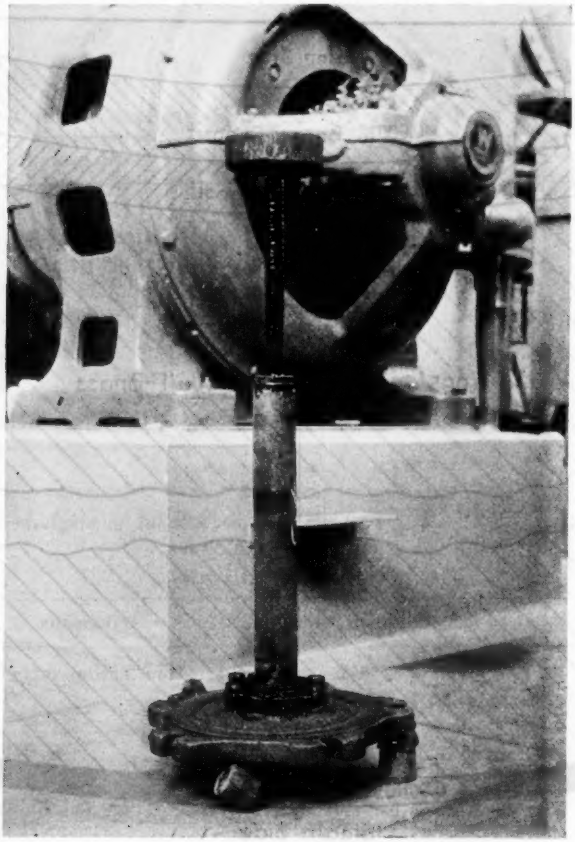

FIG. 11. ELECTRODE

outside is mainly copper and zinc from the tube itself, and contains a certain amount of organic matter, probably oil. The deposit analyses are recalculated on a dry basis in table 2. It will be seen that the largest part of the scale is copper and zinc. It might be assumed that the brown deposit would contain a large quantity of sand and silt. However, according to the analysis this is not so.

The content of silica and organic matter is not much different in the green from the brown deposit. The principal content of the green deposit is copper and zinc, and of the brown deposit, copper and iron. The green scale is hard and compact, and seems to act as a protective against further corrosion. This is borne out by the fact that although the scale undoubtedly is a corrosion product, the general thinning of the tubes is very small indeed. A tube from No. 7 condenser which had been in service nearly three and one-half years had a wall thickness of 0.068 inch. A tube from No. 9 condenser, which had been in service one and three-fourth years averaged the same thickness. The nominal thickness of No. 16 B.W.G. is 0.065 inch. The purpose of the 1 per cent tin in admirality brass is just that, to give a compact product of corrosion. Although the analysis does not show it, there is no doubt some tin in the green scale. Unfortunately, the green scale has a poor coefficient of heat transfer, although better than the brown deposit. The actual values have not been measured, but the obtainable vacuum gives a good indication. By washing the condenser with high pressure water or cleaning with new, tight fitting rubber plugs, all the brown deposit is removed but not the green scale—the vacuum can be brought to within 0.2 to 0.15 inch of the vacuum for a new condenser. By sand-blasting, where at least 50 per cent of the green scale also is removed, the vacuum may be improved to 0.1 to 0.05 inch within the vacuum for a new condenser. That part of the green scale which has been removed by sand-blasting has consequently improved the vacuum 0.1 inch. It is true that sand-blasting tends to shorten the life of the tubes for the reason that it removes the protective scale, but the wear is not appreciable (the weight loss by one sand-blasting averages 0.4 per cent) and so far no corrosion has been found to originate from this method of cleaning.

The relative thickness of the various deposits have been measured with a microscope and found to average as follows:

	inches
Black outside	0.00005
Green nearest tube wall, inside the tube	0.0001
Brown, on top of the green	0.00016

These values are only average for the few tubes on which the scales were measured. The deposits are illustrated in figure 10.

Electrolytic protective system

Both condensers are equipped with an electrolytic protective system, which consists of sixteen cast iron anodes placed against the tube sheet in each end of the condenser. The anodes are insulated from the condenser, and supplied with direct current from a small motor generator set. The tube sheet and tube bundle is connected to the negative side of the generator. The purpose of this system has been explained in the theoretical section above. The large masses of iron and brass in contact with each other form an electrolytic cell, where normally the iron is anodic and the brass cathodic.

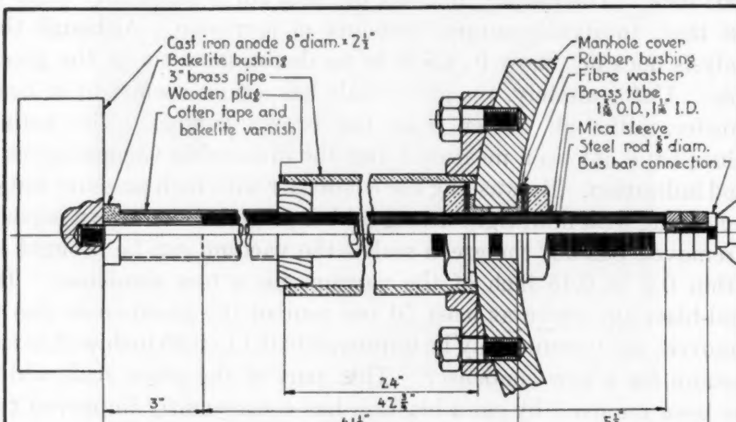

FIG. 12. ELECTRODE ON NOS. 7 AND 8 CONDENSERS

But any outside current may reverse the process, and start corrosion on the brass side of this element. Thus it might easily happen that stray currents from outside electric equipment will create a potential difference in the wrong direction, which might have a serious effect on the condenser tubes. The situation in the steam plant of San Diego Gas and Electric Company is a good illustration of the effect of stray currents. This company furnishes 500 volt direct current, to the local street railway company, and a large amount of this current was returned to the steam plant through pipe lines, cables, etc. With the coöperation of the railway company, this condition was remedied, and the condenser tube losses were reduced from 38 to 6 tubes per

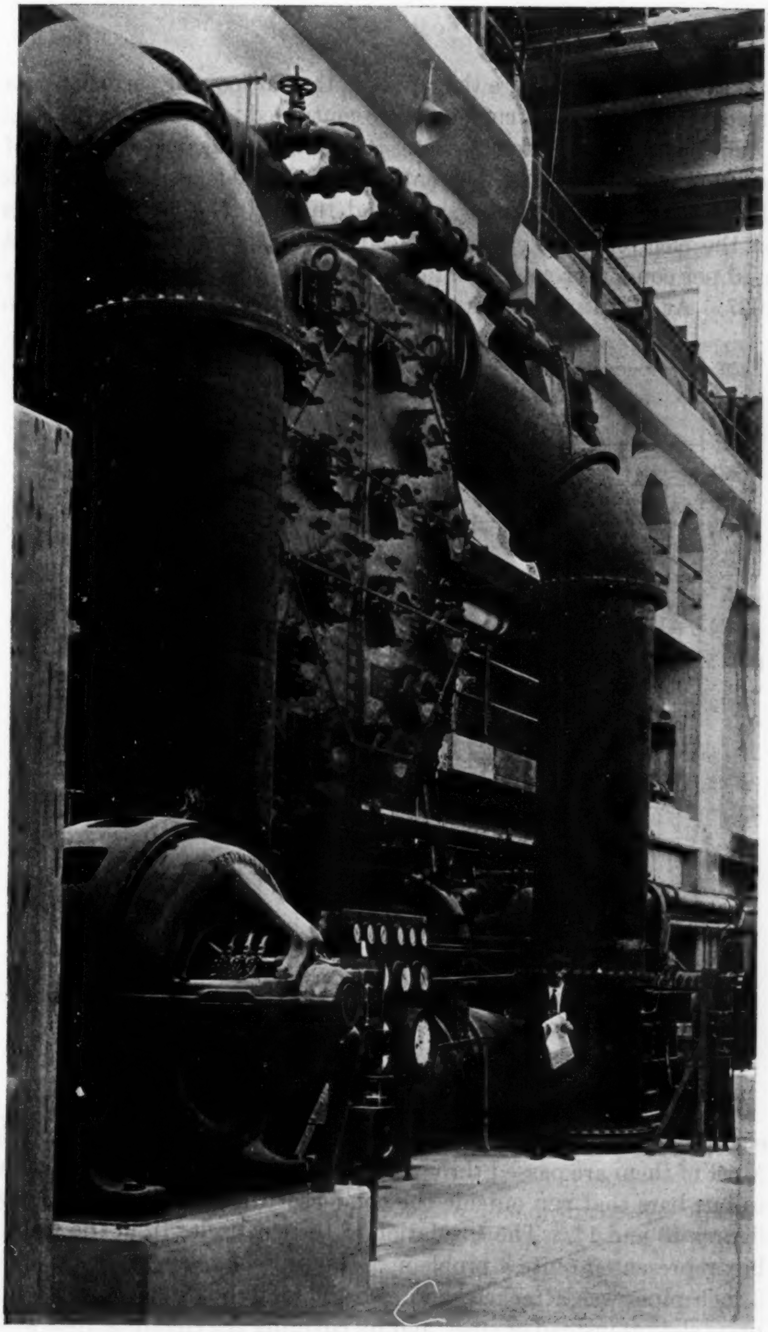

FIG. 13. OUTSIDE VIEW OF CONDENSERS WITH BUS BARS

month. The chances are that most of the subsequent corrosion was started before the stray currents were controlled.

The electrolytic system at Long Beach insures against corrosion of condenser tubes by stray current, and causes a deposit of iron from the electrodes on the tube sheet and tubes. The cast iron heads on the electrodes are easily replaced and inexpensive. The current used per condenser was 80 amperes at seven volts up to September, 1927. At that time, it was reduced to 60 amperes. A picture of an

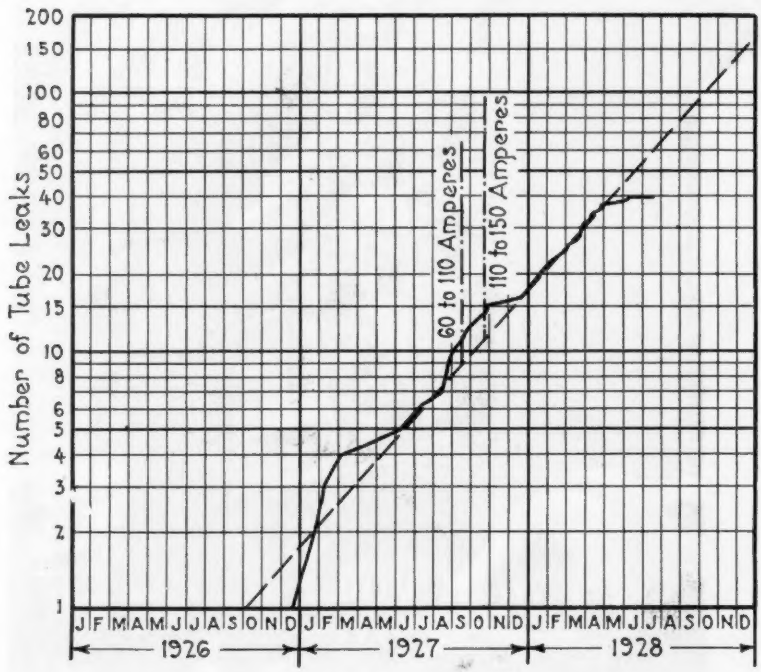

FIG. 14. ACCUMULATED TUBE LEAKS NO. 9 CONDENSER ON SEMI-LOGARITHMIC PAPER

electrode is shown in figure 11 and a detailed drawing in figure 12. Most of them are passed through a manhole cover and are connected to bus bars that run outside the condenser water box, illustrated in figures 13 and 14. The insulation of the electrodes from the water-box represented quite a problem. The protective sleeve, which is a 3 inch pipe, was attacked, and also the waterbox itself. By using brass sleeves instead of steel, and by covering the electrode rods with

several layers of cotton tape coated with bakelite, the trouble seems to have been overcome.

The replaceable cast iron heads measure 8 inches diameter by $2\frac{1}{2}$ inches thick, and weigh 37 pounds each. They are replaced, when the weight has been reduced to an average of 6 pounds. Between April, 1926 and December, 1927, a total of 71 electrode heads were replaced on No. 7 condenser, and 61 on No. 8 condenser. The aver-

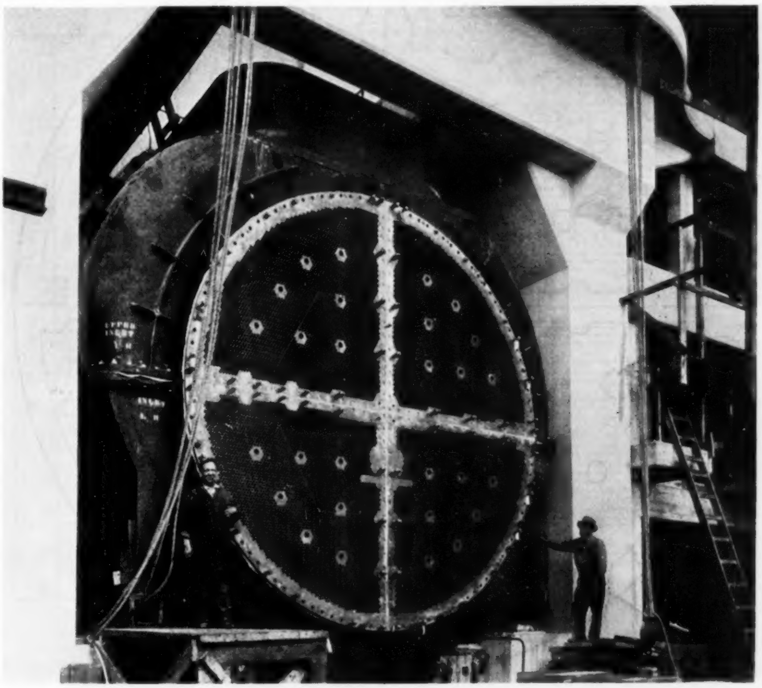

FIG. 15. TUBE SHEET NO. 9 CONDENSER

age replacement amounts to 3.1 heads per month per condenser at a cost of material of $6.40. The average daily loss in weight per condenser is 3.24 pounds of cast iron. The reduction in weight and volume of these heads is preceded by a softening of the surface to the consistency of hard mud. It can easily be cut with a knife. When this softening has reached about $\frac{1}{4}$ inch it breaks loose as a scale and the softening of the underlying metal continues. To look at a used

electrode head, and before the soft matter has been scraped off, one would think it were built up of layers. The surface matter contains 12.3 per cent carbon and 43.9 per cent iron, which indicates that the pure iron has been removed. Ordinary cast iron contains 3 to 4 per cent carbon.

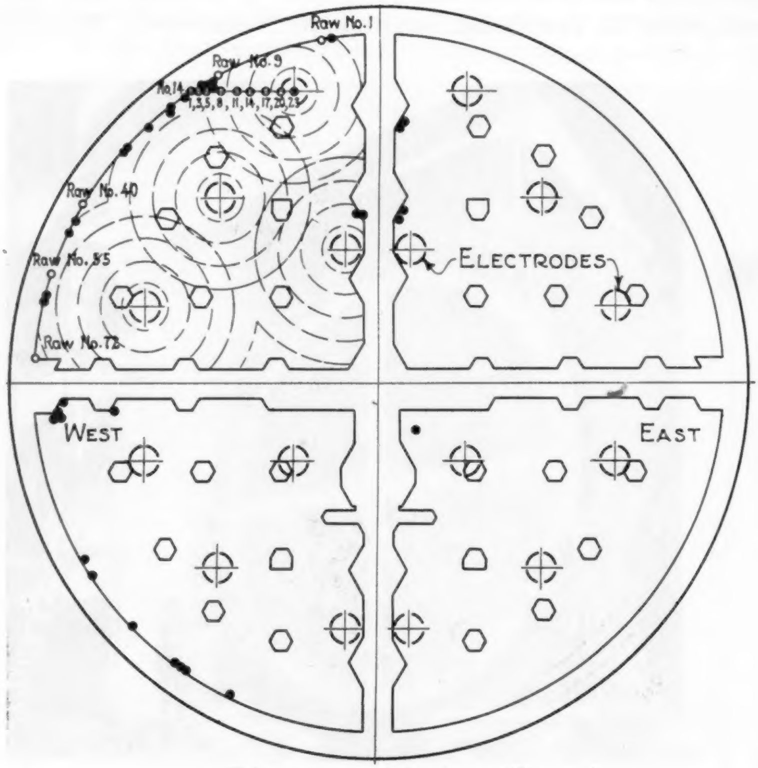

FIG. 16. TUBE SHEET NO. 9 CONDENSER (LOCATION OF TUBE LEAKS AND ELECTRODES)

Corrosion in No. 9 condenser

The development of corrosion in this condenser gives a good illustration of the operation of the electrolytic protective system. The condenser tubes are of admiralty brass, manufactured by the Ameri-

can Brass Company and are protected by an electrolytic system of thirty-two anodes, similar to condensers 7 and 8.

The unit was started in operation on July 10, 1926, and the first tube leak occurred December 23, 1926, after five and one-half months service. From that time to May, 1928, a total of 37 leaks developed at a slowly increasing rate, as will be seen on the accumulative tube leak chart, figure 14. The rate of tube leak development dropped off to practically nothing on May 1. Plotted on a semi-

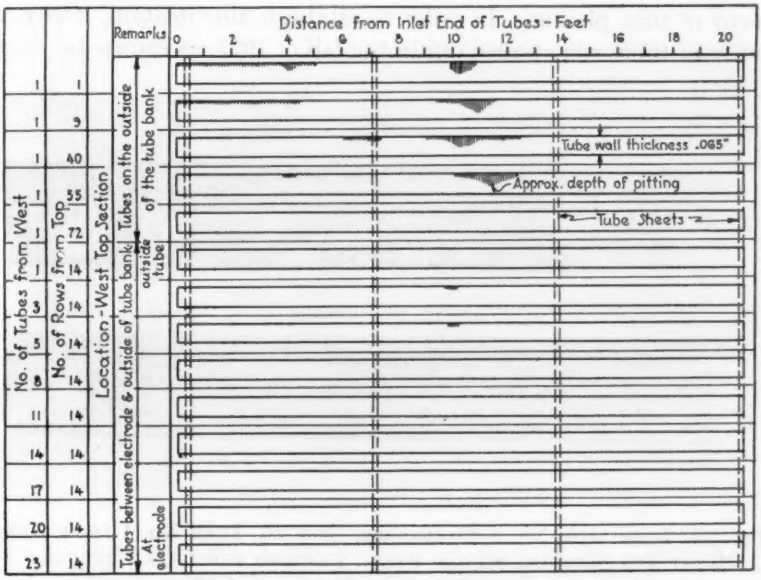

FIG. 17. PITTING OF TUBES IN NO. 9 CONDENSER, AFTER 15½ MONTHS SERVICE

logarithmic chart, the accumulative leakage curve is approximately a straight line up to that date (May 1, 1928).

The original electrode current was 60 amperes for the whole condenser. When the tube leakage became excessive, the current was raised to 110 amperes, in September, 1927, and to 150 amperes in October, and has been held at this figure since that time with an average cast iron consumption of 12 pounds per day from the electrodes. It is very probable that the reduction in tube leaks in May, 1928, was caused by the increase in electrode current in the fall of

1927. The pitting that occurred in the intermediate period had already been started when the current was raised, and corrosion continued in these places.

A photograph of the tube sheet is given in figure 15 and a sketch with location of leaks, marked in figure 16. It will be seen in the latter illustration that nearly all leaks have occurred on the outside of the tube bundle, where the protection from the electrodes would be least effective. It was therefore reasonable to believe that some relation existed between the electrode location and the development of tube pitting. In order to establish this relation, if any, a series of tubes were pulled out in the fall of 1927, as shown by rings

Fig. 18. Tube from No. 9 Condenser, Row 56, Tube No. 1 from West, West Top Section, Second Pass. Plugged for Leak February 9, 1927. Removed March 13, 1927

on figure 16. One of these was located directly behind an electrode, and the others at increasing distance from it. Tubes were also pulled around the circumference of the tube bundle in the upper West quarter. The location of the pits and their relative depths are indicated graphically on the chart, figure 17. It will be noted that the corrosion is most severe on the outside of the tube bundle, and generally in the middle of the tube length, between the two tube support sheets. The tubes farthest away from any electrode shows the worst pitting, and the one directly behind the electrode shows no pitting. Photographs of two outside tubes from this section figures 18 and 19, give an indication of how rapidly the corrosion

spreads, just like a disease. The tube on figure 18 and Row 56, was removed after 9 months service, and has a corroded area a few inches long, but the pits were deep enough to cause a leak. The tube on figure 19 is from the adjacent Row 55, (marked on the tube sheet figure 16 and on figure 17). It was removed after seventeen months service, and has a corroded section which is several feet long. Evidently the corrosion spreads and might eventually cover the entire length, unless preventative measures are taken in the meantime. This is entirely in agreement with the electro-chemical theory.

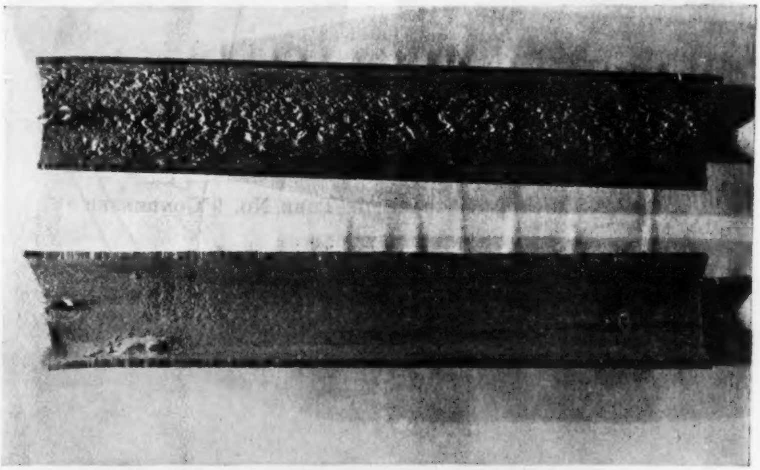

FIG. 19. TUBE FROM NO. 9 CONDENSER, ROW 55, TUBE NO. 1 FROM WEST, WEST TOP SECTION, SECOND PASS. REMOVED FOR INSPECTION NOVEMBER 1, 1927

When a pit has been formed the bottom is covered with deposit of some sort and the underlying area is anodic. A potential will also be set up between this area and the surrounding metal, which generally will attack the surrounding area, as these parts have a more dilute deposit of solution. When a pit has started the tendency is nearly always for the corrosion to deepen and spread.

The photomicrographs taken from one of these outside tubes which develop a leak in the early stage of operation, figure 20, shows perfectly sound material at the cavity, and that corrosion is not due to faulty material.

Corrosion of another nature is taking place at the tube inlet ends, particularly in the first pass. The tube inlets are illustrated in

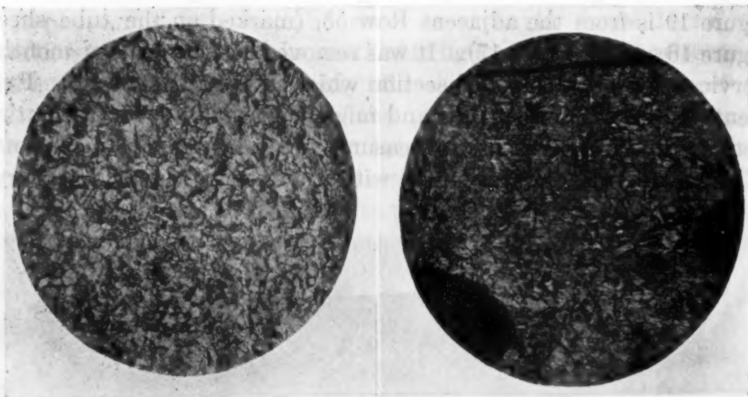

FIG. 20. PHOTOMICROGRAPH OF TUBE NO. 9 CONDENSER

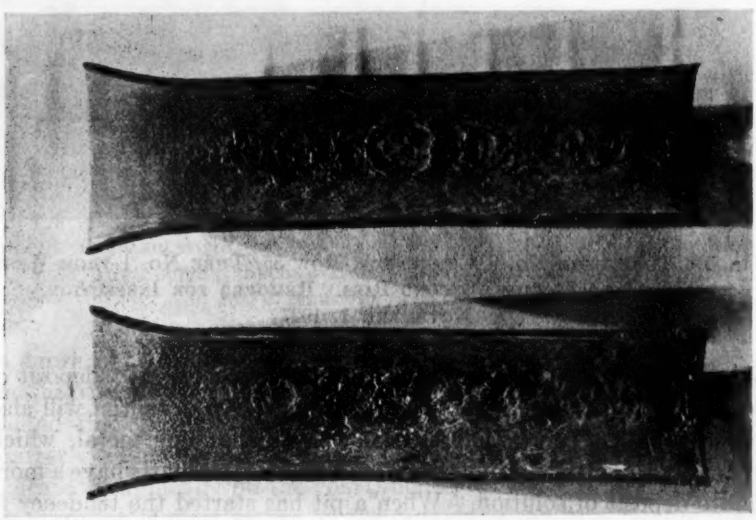

FIG. 21. INLET ENDS OF TUBE NO. 6, AND TUBE 18, ROW 4, EAST BOTTOM SECTION NO. 9 CONDENSER. REMOVED FOR INSPECTION JANUARY 3, 1928

figures 2 and 4, and two typical cases of corrosion are shown in figure 21 of tubes which have been in service 18 months. The appear-

ance of these corrosion pits indicate that the corrosion is caused by air in the water. The pits are bright. The distribution of this particular kind of pitting varies with the location of the tube in the condenser. The upper rows in the first pass have deep pits in the upper part of the tube inside, where air would collect if liberated from

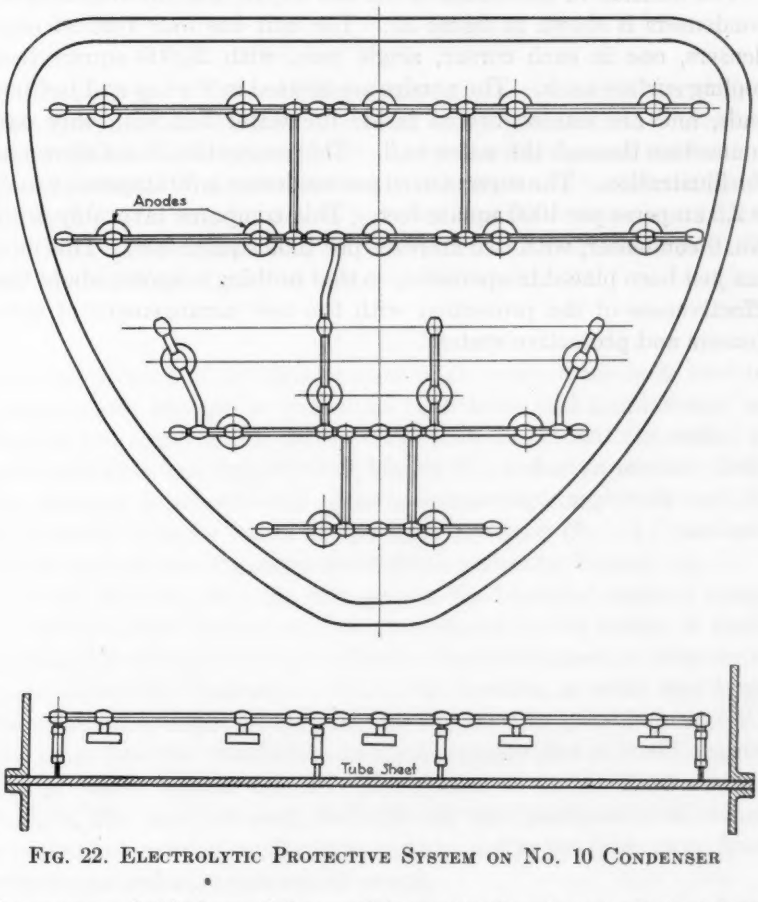

FIG. 22. ELECTROLYTIC PROTECTIVE SYSTEM ON NO. 10 CONDENSER

the water. Aside from this row of deep pits there is not much pitting around the circumference. But the pits have a depth of probably one-third the wall thickness, and extend in some cases beyond the tube sheet into the active part of the tube. It is probable that the tube will be punctured outside the tube sheet before the corrosion inside has progressed far. It might also be that this hole in the tube

will provide escapement for the air and slow down further corrosive action, but it cannot stop it. The lower rows in the first pass have a more even distribution of corrosion around the circumference of the interior tube surface, and not very severe, as yet, in any one place. No tube leaks have yet developed from this kind of corrosion.

The location of electrodes in the new 94,000 kw. turbo-generator condensers is shown in figure 22. The unit has four vertical condensers, one in each corner, single pass, with 20,000 square feet cooling surface each. The anodes are located in the top and bottom ends, and are interconnected inside the water box with only one connection through the water wall. This connection is not shown in the illustration. The current used per condenser is 50 amperes, which is 2.5 amperes per 1000 square feet. This compares favorably with No. 9 condenser, with two amperes per 1000 square feet. This unit has just been placed in operation, so that nothing is known about the effectiveness of the protection with the new arrangement of condensers and protective system.

SUCCINCHLORIMIDE FOR THE TREATMENT OF SMALL QUANTITIES OF POTABLE WATER[1]

By Cyrus B. Wood[2]

The purpose of the work here reported was to find, if possible, a water disinfectant suitable for small scale preparation of potable water that would be an improvement on the disinfectant used in the present official Army method for the preparation of potable water in the field. The work to date is reported because of the appointment of a joint board representing both the Chemical Warfare Service and the Medical Department to continue that search.

HISTORICAL

A full account of the development of the various methods used to render water potable in quantities both large and small would be beyond the scope of this article. For such an account the reader is referred to the excellent work of Mason (1); a shorter account, dealing more in detail with the chlorine-containing compounds used in such work, is to be found in the book by Race (2). An excellent recent work discussing water disinfection is that by Buswell (3).

Suffice it to say that the discovery of the bacterial origin of many of our common diseases and the part played in the spread of these diseases by water and food resulted in the development of large scale methods for the destruction of harmful bacteria in order that large water supplies might be delivered to the users in potable form. At the same time the purification of small supplies and of small quantities of water became urgent. The armies of the civilized nations realized the need of such methods for the purification of water supplies in large and small camps and also out in the field, away from permanent and semi-permanent camps.

The methods of use in the small scale purification of water are fully described and discussed in texts on hygiene, sanitation and related

[1] From the Department of Preventive Medicine and Clinical Pathology, Army Medical School, Washington, D. C. This article appears concurrently in the October issue of the "Military Surgeon." (Editor.)

[2] Major, Medical Corps, U. S. A., Washington, D. C.

subjects (4, 5, 6). Their development has, naturally, been influenced by the methods that proved of use in large scale water disinfection; still, this small quantity problem has features that differ from large and from small scale water disinfection.

The simplest method of rendering water potable is boiling. Boiled water is, however, definitely unpalatable; furthermore, the boiling of water before drinking is seldom practicable in field use.

The next simplest method is the addition to water of a chemical or of chemicals, and several have been used in this way. Years ago potassium permanganate was used by the British; the dosage used varied with the water treated, and sufficient chemical was added until a pinkish tint remained for twenty or thirty minutes. Long ago, also, the British used bleaching powder; approximately 25 grams were added per water cart quantity (about 100 gallons). Later, tablets of acid sulfate (sodium acid sulfate, with saccharin and oil of lemon) were used for single canteen quantitites. This last has the disadvantage, first, of attacking the metal of the canteen and, second, of preventing much of the normal amount of calcium from being absorbed (hence is undesirable for continued use). Potassium permanganate is said to be a specific destroyer of cholera organisms (4), but is far from being an active bactericidal agent for all organisms to be found in natural waters.

Col. C. R. Darnall, M. C., designed (7) a box filter, about the perforated syphon outlet of which is placed a cloth on which is caught freshly precipitated aluminum hydroxide. Water is run into this filter from a barrel set on a rack above it; below is placed a second barrel in which the filtered water is stored. This is a small scale modification of the principle employed in rapid sand filtration plants, use being made of an artificial "schmutzdecke." This method is applicable to permanent and semi-permanent camps, but not to small, highly mobile bodies of troops.

Col. W. J. Lyster, M. C., proposed (8) the field method for preparing potable water that is the present official one. It consists in the use of a bag of special weave, of inverted cone shape, with a capacity of 36 gallons (= 136 liters), equipped with five or six spring faucets near the bottom. It is mounted on a folding rim, this feature making for ready transportability, and weighs, empty, less than 8 pounds. With the bag is furnished a filtering cloth, allowing rough filtration to the extent of removal of sticks, leaves and larger suspended particles. The disinfecting agent used is bleaching

powder, which is issued in 1 gram quantities in sealed brown glass tubes; lots of these tubes in cardboard boxes are issued by the Quartermaster Corps, as are also the bags.

For use the bag is suspended and filled, through the filtering cloth if necessary, with water. One or more (the number to be directed by a Medical Corps officer) tubes of bleaching powder are broken and the contents shaken into a cup containing a little water. This mixture is stirred, made gradually thinner with more water, emptied into the bag and the whole stirred well. After standing thirty minutes the water is considered potable.

One tube of bleaching powder containing 1 gram of that compound added to a Lyster bag (36 gallons, 136 liters) of water is a dosage of 7.353 mgm. per liter, or 7.353 p.p.m. The chlorine dosage depends upon the titer of the powder at time of use; if (for the sake of simplicity) its titer is 27.2 (i.e., 1 gram furnishes 0.272 gram available chlorine), the addition of one tube of this powder to a Lyster bagful of water means the addition of 272 mgm. available chlorine to 136 liters, or 2 mgm. per liter, or 2 p.p.m. If the bleaching powder has a titer of but 13.6, a tube of such powder to this quantity of water is the use of a dosage of 1 p.p.m. available chlorine.

This method was used extensively during the World War, and the correspondence on it in the Surgeon General's Office deserves mention. First, in point of time, should be mentioned the confusion that was almost inevitable because of the fact that this bag and its accompanying filter and the bleaching powder tubes were and are issued by the Quartermaster Corps, although their use was often entirely in the hands of the Medical Department.

More important is the fact that bacteriological checks of the bleaching powder on hand showed such unsatisfactory and erratic bactericidal power as to render necessary a physical inspection of the stocks of tubes delivered overseas. These examinations showed the tubes themselves to be in unsatisfactory physical condition, unreasonably large percentages of poorly sealed and of exploded tubes being found. Poor packing also was found, the separate containers (each at that time holding 60 tubes) not being well enough filled with both tubes and packing to prevent injury to the tubes especially in the top and bottom layers incident to the hurried handling they had received. Chemical examinations of the bleaching powder held in tubes picked at random from large stocks showed the available chlorine content to be unreasonably low.

Meanwhile the best was being made of the bleaching powder tubes on hand, Medical and Sanitary Corps officers recommending often as many as five tubes to be used to each Lyster bagful of water. Such a water has, of course, a definite taste, and was quite naturally blamed for any physical ills that might develop within the next several hours, days, and even weeks subsequent to its use.

In 1921 the Surgeon General interested the Quartermaster General in the condition of the supplies of bleaching powder tubes on hand, and through that office sample boxes from the several storage depots were sent in for examination (9). As a result of this survey recommendations as to more careful packing were made, and a deterioration rate of the bleaching powder in these tubes of approximately one-sixtieth (0.5 of the original titer of 30 to 32 per cent) per month was determined. In this connection it is interesting to know that McDonnell and Hart (10) have announced a monthly deterioration rate of commercially packed bleaching powder of 1.08 per cent of its original 30 to 35 per cent free chlorine content.

Fairhall (11) suggested adding to the equipment for the field preparation of potable water ampoules containing a solution of orthotolidin (12) and clear glass tubes holding each 1 gram small sodium thiosulfate crystals; he recommended the modification of the original procedure described above by adding to the water under treatment a sufficient number of tubes of the bleaching powder on hand to give a color with the ortho-tolidin solution which persists for thirty minutes, then adding the sodium thiosulfate crystals, stirring well, and pronouncing potable very soon after this last step. These recommendations were later adopted.

Hitchens (13) made useful observations on the shades of color given by the ortho-tolidin solution recommended by Fairhall, proposed more specific directions, and placed emphasis again on the use, in the absence of other methods, of tincture of iodine in the dosage of one drop to a canteenful (this equals approximately one drop per liter) to render water potable.

In their extensive study of a large number of compounds and mixtures containing free or available chlorine as antiseptics Dakin and his coworkers (4, 14, 15) found that the compound p-dichloraminosulfon benzoic acid can be used as a small scale water disinfectant. This compound is now on the market under the name "halazone;" it is put up in tablets, each for the treatment of a quart

or a liter of water; each tablet contains 4 mgm. of that compound. This is, the writer believes, the first proposal of the use of an organic compound containing positive chlorine for water disinfection.

A study was made (16) of thirty bottles (each containing 100 tablets) of "halazone" and these tablets were found to deteriorate at the rate of approximately 10 per cent yearly; each table containing 4 mgm. "halazone" today will be found a year from now to contain but 3.6 mgm.

While this study was in progress tablets were furnished by the manufacturer of a preparation known as "nuklorene" (16), who hoped that it would prove useful as a water disinfectant. It was found to be far inferior to "halazone;" in fact, was practically worthless bactericidally. The writer mentions this incident because of his strong suspicions that the active principle of this preparation was sodium p-toluene sulfonchloramide (chloramine-T); if this is correct, it constitutes a second proposal of an organic compound as a water disinfectant. This last named compound was announced useless as a water disinfectant by Dakin and Dunham (15).

More recently Maj. C. H. H. Harold of the Royal Army Medical Corps has proposed (17) and developed a method for the preparation of small quantities of potable water that seems to answer the field problem quite well. He uses as the disinfectant agent chloramine, NH_2Cl, which will be found discussed at some length by Race (2) and is used for large scale water disinfection in some cities on this continent. Referring the reader to Harold's articles for the details of this method, the writer must state for the sake of completeness that Harold recommends the forming of chloramine or of dichloramine ($NHCl_2$) by adding to the water under treatment first a tablet of ammonium carbonate, then a small volume of chlorine water. The compounds named are formed promptly, depending upon the use of one or of two volumes of chlorine water to a unit quantity of ammonium carbonate. Certain advantages of this method are obvious; the materials are quite available and are cheap; the method is not at all complicated; the disinfecting agent is formed right in the water treated, hence its deterioration does not enter into the problem. However, the stability of the ammonium carbonate tablets and of the chlorine water must be considered; furthermore, the two-reagent feature of this system will, the writer fears, be considered by many a real disadvantage.

THEORETICAL

To be of use for the Army method of preparing potable water in the field an organic compound containing positive chlorine must be a solid at ordinary temperatures and pressures. A liquid compound of this nature would have certain disadvantages, in that it would escape readily from its container, once that container became cracked (not necessarily broken), and would react with water sufficiently promptly to show corrosive properties more or less readily. A gas would escape, possibly explosively, from its container, were that container handled too roughly; furthermore, for the use of a gas an apparatus would be needed differing from the present equipment.

Such a solid organic compound containing positive chlorine should possess the following properties: (*a*) prompt reaction with water, with resulting prompt bactericidal action on the organisms encountered in natural waters; (*b*) stability to a degree allowing prolonged storage; slight or negligible deterioration for a period of time expressible in years, rather than in weeks or months; (*c*) non-toxic action on the human body.

Bleaching powder (calcium chloro-hypochlorite) in the form of the ordinary grades (titer 30 to 35 per cent available chlorine) has been found definitely wanting in the second characteristic, stability (9, 10).

p-dichloraminosulfon benzoic acid, "halazone," has the first characteristic to an imperfect degree, reacting so slowly with water that it has been found necessary to put in its tablets a quantity equal to the weight of that compound, of sodium carbonate or of sodium borate, in order to make its solubility in water near a practical degree (15).

Sodium toluene p-sulfonchloramide, chloramine-T, the water soluble wound disinfectant developed by Dakin and coworkers (14), has too slow a bactericidal action (4) to be of any use as a water disinfectant.

Some readers may wonder, as did the writer, about the bactericidal power of benzene sulfondichloramide, $C_6H_5 \cdot SO_2 \cdot NCl_2$, a compound closely related chemically to chloramine-T and dichloramine-T (4, 14). The writer made a few grams of this compound (October, 1926) and found that a few tiny crystals scattered on the surface of water containing a very little potassium iodide, liberated free iodine promptly. Some of this compound was accordingly sent for bac-

teriological study, and was reported too sluggish bactericidally to deserve the name of a water disinfectant (18).

The writer attempted the preparation of tetrachlorohexamethylenetetramine (19) and of monochloroguanidine (20) without success; hence can make no statement as to the degree to which each of these compounds possesses the characteristics mentioned above.

Personal communication with Dr. T. J. Albert (formerly with the Medical Research Division, Edgewood Arsenal, Md.) makes the writer doubt the stabilities of acetylchlorcarbamide (21) and of most, if not of all, of the interesting series of substituted ureas developed by Chattaway and his coworkers.

The writer's attention was attracted to the compound succinchlorimide primarily because it resembles phthalic acid in imide formation, anhydride formation, and other ways. The salts of succinic acid are to be found in certain non-poisonous fruits, such as lettuce and unripe grapes. Furthermore, the sodium, potassium and ammonium salts of succinic acid have been used in medicine as internal remedies, in dosages of 5 to 15 grains (0.3 to 1.0 gram). Succinchlorimide reacts with water to form a simple amino acid, succinamic acid; hence, the prospects of this compound being of low toxicity seemed quite good.

The preparation of this compound, stability studies, toxicity studies and bacteriological studies made on this compound will be given later (see Experimental).

Compounds containing positive chlorine are believed to act bactericidally in a three-fold manner (2): they act (*a*) by directly oxidizing organic matter, (*b*) by directly chlorinating organic matter and (*c*) by toxic action on such low forms of life. The writer doubts that it will ever be possible to separate these actions, as the temperatures and humidities demanded by such forms of life leave little room for varying experimental conditions sufficiently to rule out either of the first two actions named.

PROPERTIES OF SUCCINCHLORIMIDE

Succinchlorimide is a crystalline compound, colorless, with slight odor of chlorous nature that is not at all strong in crystals of highest purity. It has a melting point of 148–9°C. and can be fused and allowed to solidify repeatedly, apparently without change, under temperatures of 170°C.; above that temperature it decomposes.

It has a somewhat saline taste with a definite chlorous quality that is moderately persistent.

Succinchlorimide dissolves quite readily in water, especially if in finely divided state, to make approximately a 1 per cent solution (20°C.). It is fairly soluble in chloroform and in ethylene chloride (symmetrical dichloroethane), and sparingly soluble in benzene, toluene and acetylene tetrachloride (symmetrical tetrachloroethane) at ordinary temperatures. All of the solvents just named dissolve this compound in appreciable quantities when hot, and can be used as recrystallizing solvents.[3] Oddly, succinchlorimide is practically insoluble even in hot carbon tetrachloride.

Acetone and ethyl acetate dissolve this compound in fair quantities at ordinary temperatures, apparently without change.

Methyl alcohol seems to dissolve succinchlorimide without change; such a solution, on being evaporated to dryness, leaves a residue that appears unchanged. Such cannot be said of ethyl alcohol, however; a reaction takes place at temperatures near 50°C. which may be quite brisk, and the residue gives no evidence of containing available chlorine.

As would be expected in the case of a compound containing positive chlorine, aqueous solutions of this compound react promptly with potassium iodide, liberating free iodine. The compound succinchlorimide reacts with water according to the reaction:

$$\begin{array}{l} CH_2\cdot CO \\ \cdot \\ CH_2\cdot CO \end{array} :NCl + 2\ H_2O \longrightarrow \begin{array}{l} CH_2\cdot COOH \\ \cdot \\ CH_2\cdot CONH_2 \end{array} + HOCl$$

succinchlorimide — succinamic acid — hypochlorous acid

The simple amino acid formed on hydrolysis probably explains the low toxicity of this compound.

EXPERIMENTAL

A. Preparation of succinchlorimide

1. (a) *Preparation of succinimide by treating succinic anhydride with dry ammonia* (22, 23). One hundred grams succinic acid, dried at 100°C., are heated in a 300 cc. retort with 65 grams phosphorus oxychloride at a temperature of 100–120°C. until hydrogen chloride is no longer evolved; during this step the stem of the retort is elevated to serve as a reflux condenser. After hydro-

[3] The writer plans soon to determine more accurately these solubilities.

gen chloride is no longer evolved the stem of the retort is lowered and the contents distilled; the distillate is collected after each single drop solidifies (first few drops discarded). The product is succinic anhydride, practically pure; recrystallization from chloroform gives a product melting at 119–120°C. Reaction:

$$\begin{array}{l} CH_2\cdot COOH \\ \cdot \\ CH_2\cdot COOH \end{array} \xrightarrow{POCl_3} \begin{array}{l} CH_2\cdot CO \\ \cdot \\ CH_2\cdot CO \end{array} :O$$

One hundred grams succinic anhydride are fused in a 300 cc. retort and a stream of ammonia gas is led through a column of soda lime into it until the ammonia is no longer absorbed (odor). The stem of the retort, elevated during this step; is then lowered and the contents rapidly distilled over a free flame. (Previous heatings of the retort are done on a sand bath or a Wood's metal bath.) A certain amount of charring seems unavoidable in this step; the distillation is accordingly stopped as soon as the distillate, at first clear and colorless, becomes slightly discolored (yellowish). Recrystallization of this product from acetone gives a product melting at 123–125°C. Reaction:

$$\begin{array}{l} CH_2\cdot CO \\ \cdot \\ CH_2\cdot CO \end{array} :O \xrightarrow{NH_3} \begin{array}{l} CH_2\cdot CO \\ \cdot \\ CH_2\cdot CO \end{array} :NH$$

1. (*b*) *Preparation of succinimide from ammonium succinate.* Crystallized or powdered ammonium succinate is placed in a round bottomed flask or in a retort in sufficient quantity to fill it half or a bit more. If a flask is used, it is fitted with a single outlet tube of wide diameter. Heat is applied (free flame) so as to get rapid and uniform temperature rise. The contained ammonium succinate melts, then ammonia and steam are evolved and succinimide distils over. By rapid heating very little loss from charring occurs. Reaction:

$$\begin{array}{l} CH_2\cdot COONH_4 \\ \cdot \\ CH_2\cdot COONH_4 \end{array} \longrightarrow \begin{array}{l} CH_2CO \\ \cdot \\ CH_2CO \end{array} :NH + NH_3 + 2\,H_2O$$

(The writer has repeatedly tried the method (24) of heating ammonium succinate in an open dish to temperatures near 200°C., and reports most erratic results.)

2. Preparation of succinchlorimide from succinimide. The preparation of succinchlorimide by adding chlorine gas and also by adding a strong solution of bleaching powder to a solution of succinimide in 15 per cent sodium hydroxide at low temperatures (0°–10°C.) (25) was unsuccessful in the writer's hands.

The writer has been able to prepare succinchlorimide by passing a slow stream (separate bubbles at a rate allowing counting) of chlorine gas into water containing approximately 5 per cent of succinimide and 5 per cent of sodium bicarbonate or 3 per cent sodium carbonate, the solution being chilled to temperatures below 10°C. The succinchlorimide forms quite promptly in solutions made with sodium bicarbonate, and after some delay in solutions with

sodium carbonate; it collects at the surface of the solution as a white crystalline product. Recrystallization from chloroform, ethylene chloride (symmetrical dichloroethane), acetylene tetrachloride (symmetrical tetrachloroethane), benzene or toluene gives a product that contains the theoretical amount of chlorine (26.560 per cent) and that melts at 148–9°C. Reaction:

$$\begin{array}{ll} CH_2{\cdot}CO & \\ \cdot & :NH \\ CH_2{\cdot}CO & \end{array} \xrightarrow{Cl} \begin{array}{ll} CH_2{\cdot}CO & \\ \cdot & :NCl \\ CH_2{\cdot}CO & \end{array}$$

B. Stability of succinchlorimide

The many factors influencing the rate of deterioration of chemical compounds need but be mentioned to show how complex a subject this is and how many-sided a study could be made of this or of any compound. The purity of the compound, the nature of the impurities (if any are present), the degree of access of air, the qualities of the air that may gain access to it, the range of temperature to which it may be subjected in storage, the accessibility of light, the character of that light—these are the most obvious factors influencing the deterioration of chemicals. The following brief studies were made, choosing them because of the factors that have undoubtedly played a part in the deterioration of bleaching powder (9).

1. Under steadily changing air of 50 per cent humidity (26) and exposure to northern light for fifty days bleaching powder, "halazone" and succinchlorimide were studied with the following results:

	BLEACHING POWDER	"HALAZONE"	SUCCIN-CHLORIMIDE
Per cent free Cl, 0 day	21.9	25.5	25.6
Per cent free Cl, 50 days	16.9	25.06	25.4
Loss	5.0	0.44	0.2
Per cent original Cl lost	22.8	1.72	0.78

(The analyses given represent titrations of 0.100 gram samples with thiosulfate solution. Each figure is the average of three titrations of such samples. The powders were thoroughly mixed before collecting these samples.)

2. Samples of "halazone" and of succinchlorimide were studied in clear glass tubes, cotton-plugged; each tube was about half filled with contents. Half of these tubes were placed in a bacteriological incubator where a temperature of 37.5°C. was maintained for fifty

days. The remaining tubes were kept on the shelf close to a north window (no direct sunlight) for the same period.

	"HALAZONE"		SUCCINCHLORIMIDE	
	Room temperature, light	Incubator, dark	Room temperature, light	Incubator, dark
Per cent free Cl, 0 day	24.0	24.0	25.6	25.6
Per cent free Cl, 50 days	23.65	23.0	25.56	25.6
Loss	0.35	1.0	0.05	0.0
Per cent original Cl lost	1.46	4.16	0.195	—

The succinchlorimide loss at room temperature in the above table is within the limits of experimental error, as is the figure of 25.7 per cent free chlorine given on analysis of other portions of this same sample at an age of two hundred days (June 22, 1926 to January 8, 1927).

3. Capt. D. W. Fetterolf, ret.,[4] (27) found that approximately 0.5 gram quantities of this compound that had been kept in formalin-hardened gelatin capsules sealed with a gelatin solution in an ice box (± 40°F.) for one year showed a chlorine content at the end of that period of 26.10 per cent (theoretical, 26.56).

4. The writer has a bottle containing about 65 grams of this compound that he made during the summer of 1926. This bottle has been about the laboratory and, for several months, on a certain desk in the Surgeon General's office since that time. It has had no special care or attention, except that it has never, it is believed, been exposed to direct sunlight. It has never been in an ice box. Its stopper has never been out for more than a few moments at a time. Recently, (May 31, 1928) an analysis showed the presence of 26.08 per cent chlorine; it is still better than 98 per cent pure, based on its chlorine content.

The facts given in the preceding numbered paragraphs all suggest an excellent degree of stability of the compound succinchlorimide, making all due allowances for the facts that it is organic, that it contains positive chlorine in a comparatively small molecule, and that it reacts quite readily with water. It is definitely more stable than "halazone," which compound was used not only as one possessing a stability that would be of value for comparison, but also as one whose

[4] Officer in charge, Chemical Laboratory, Army Medical School, 1923–1927.

stability should be exceeded by the compound sought for in this study.

TABLE 1

Bactericidal results with succinchlorimide

	TEST FOR THE PRESENCE OF B. COLI												PRECIPITATE	BACTERIA PER CUBIC CENTIMETER
	Fermentation tubes						Confirmatory E. M. B. plates							
	24 hours			48 hours			24 hours			48 hours				
	0.1	1.0	10.0	0.1	1.0	10.0								
Sterile distilled water plus B. coli														
Control	+	+	+	+	+	+		*			*			3,000
Ca-2	0	0	0	0	0	0		0			0		Very faint	
SCI-5	0	0	0	0	0	0		0			0		Very faint	
SCI-10	0	0	0	0	0	0		0			0		Very faint	
SCI-5-m	0	0	0	0	0	0		0			0		Faint	
SCI-10-m	0	0	0	0	0	0		0			0		Faint	
Water from Rock Creek†														
							0.1	1.0	10.0	0.1	1.0	10.0		
Control	+	+	+	+	+	+	*	*	*	*	*	*		6,000
Ca-2	0	0	0	+	+	+	0	0	0	0	0	*	Slight	
SCI-5	0	0	0	+	+	+	0	0	0	0	0	*	Slight	
SCI-10	0	0	0	0	+	+	0	0	0	0	0	0	Slight	
SCI-5-m	0	0	0	+	+	+	0	0	0	0	0	0	Slight	
SCI-10-m	0	0	0	+	+	+	0	0	0	0	0	*	Slight	

Ca, commercial grade bleaching powder.
SCI, succinchlorimide.
numbers, dosage in milligrams per liter.
m, mixture with equal weight sodium carbonate.
0, no bacterial growth.
+, bacterial growth
* presence of B. coli.
† Rock Creek water turbid before addition of chemicals; turbidity difficult to read.

C. Bactericidal power of succinchlorimide

The figures in table 1 are from the report by Capt. W. C. Cox, M. C., to the Director of Laboratories, Army Medical School, in

February, 1926. They show the fact that the first small lot of succinchlorimide examined deserves the name of being a water disinfectant.

This work has been repeated and extended by Maj. J. S. Simmons, M. C., using the compound prepared by the writer, and his results will be included in the report of the board (see Introduction).

D. Toxicity of succinchlorimide

Reference must again be made to the future report of the Board for details of toxicological studies already performed or under way. The writer directed the first series, and states here only that that first series of dogs used suggests a very low degree of toxicity for dogs on internal administration; a minimal lethal dose of 1 gram per kilogram body weight, or a higher figure, is predicted.

One case of prolonged human exposure should here be mentioned. The writer himself has been more or less actively engaged in the study and in (practically unaided) the manufacture of this compound for over two years. He has had it on his hands and arms to the elbows for hours at a time almost weekly during this period. If this compound were in any way toxic on such continued contact, he should have experienced such ill effects. There have been none This is, however, but one case.

DISCUSSION

A water disinfectant that is stable and that will render water potable not only in quantitites such as are held in a Lyster water bag, but in smaller quantities, such as are held in the canteen carried by the individual soldier, is one in which the Army is interested. The preparation of smaller tablets of this compound is under consideration by the Board now organized, with the hope that such use of this compound may be made. The question of injury to the human body on long use of this compound is also to be studied.

The development of the automobile within the memory of all readers has created an extra-governmental interest in such a tablet for the use of tourists and campers, whose vacation activities are much more general than they were even but a few years ago. Interest may also develop from intelligent inhabitants of tropical and sub-tropical regions, while the usefulness of such a compound to the personnel of expeditions to unexplored regions is obvious.

SUMMARY

The properties desired in a compound suitable for the preparation of small quantities of potable water are discussed.

A compound that seems to possess these properties is named and described.

ACKNOWLEDGMENT

Acknowledgment is due first to the Surgeon General's Office for the utmost encouragement and support in this work. Lt. Col. J. F. Siler, M. C., of that office, has been personally interested in it and has assisted the writer especially in allowing access to the correspondence on this subject in that office, and by furnishing him copies of much of that correspondence.

Acknowledgment is here made of the coöperation of the Army Medical School in the bacteriological work reported.

Further acknowledgment is due to Col. H. L. Gilchrist, M. C., Chief of the Medical Research Division at Edgewood Arsenal, Md., at the time of the start of the work with the compound chiefly dealt with above. The hearty coöperation of the following Chemical Warfare Service personnel is here acknowledged in the several conferences held: of the Chemical Division, Drs. G. E. Miller, R. L. Sebastian, J. Reichert and Mr. R. W. Peakes; of the Medical Research Division, Mr. T. P. Dawson; formerly with the Medical Research Division, Dr. T. J. Albert.

The Dow Chemical Company furnished a generous supply of acetylene tetrachloride, which is gratefully acknowledged here.

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DISCUSSION OF THE MANUAL OF WATER WORKS PRACTICE[1]

J. P. BUTTERFIELD:[2] In 1906, a material known as ingot iron was developed. Twenty-two years of service under ground, in the form of pipe lines, culverts, and sewer lines, have proved the durability of this material. It is, of course, patterned after the old irons that served with long life, so it is only logical that the long life of ingot iron for underground service will be similar to that of the old iron pipe lines.

This material is available for large water supply mains, as well as small ones, in many different types of pipe. Large mains can be furnished in welded, riveted, or lock-bar construction. The pipe can be prepared for any type of field joint. Ingot iron pipe is also available in smaller sizes; in fact, this kind of pipe can be purchased on the market in any size, quantity, or style in which steel pipe can be purchased.

Over five thousand culvert structures, located in thirty-one different states of this country, have been thoroughly inspected during the last few years. This includes ingot iron and steel, which structures were serving under normal, organic, and alkali conditions. The total average estimated life of a steel culvert, in normal service, based on these investigations, is 23.5 years. The total average estimated life of ingot iron is 40.7 years under the same conditions. This particular life, in the case of both steel and ingot iron, is based on sixteen gauge material ($\frac{1}{16}$ inch thick). Since water pipe service normally requires $\frac{1}{4}$ to $\frac{1}{2}$ inch plates, which are four to eight times this thickness, it would seem to be conservative to expect 50 per cent more service from these materials in water service than that found in culvert service, due account being taken of the probably more severe service conditions in water pipe lines. Such figures then for steel, namely, thirty to thirty-five years, agree with those established in table 45, found on page 532, of the Manual. The ingot iron expectancy, under the same comparison, would be sixty years.

[1] Presented before the New York Section meeting, May 3, 1928.

[2] The American Rolling Mill Company, Middletown, Ohio.

It is therefore conservative, in view of the greater wall thickness of steel and ingot iron water pipe, to use figures of thirty to thirty-five years for steel pipe and sixty years for ingot iron pipe, when comparing these two different types of plate pipe.

H. F. HUY.[3] In looking up the subject of Finance and Management for criticism, the first thing that impressed me to be criticised was the arrangement of the subjects thereunder. On the first page it speaks of water rates; on the third page it talks about assessments for water main installations, on the fourth and fifth pages it talks about taxation and about the fifteenth page it talks about meter rates, and so on. When the valuation subject is reached, which is a preliminary one under Financing, it has passed over fifty pages of reading matter.

The method of financing of a utility or water company is the most important part and it should be properly placed in the beginning of the chapter or, even better, following the introduction of Chapter 1, as all other subjects are subsidiary in water works practice. The subject under discussion should be first approached with articles covering valuation or cost of the installation.

The data in reference to valuation, price trends and depreciation are very well set forth in the Manual, no doubt somewhat at length, but still presented in a very concise manner for the determination of the value and cost of the property.

The paper prepared by Mr. Metcalf on Price Trends is interesting and should form a basis in valuation as it has useful information in determining values.

The items of depreciation and obsolescence should follow, as they are of next importance, in order to provide the data as to the present value of the property for determining methods for financing properties.

There are no data presented as to how properties can be financed. It would be very desirable to have an article prepared by bankers and bond houses as to methods of providing financing in building water works properties, either municipal, private or metropolitan districts. Such information should cover various methods that could be used as to ratio of bonds that could be issued against the property value and earnings of debentures, preferred stock, or the stock that might be issued to provide additional funds for completing the plant. Financ-

[3] General Manager, Western New York Water Company, Buffalo, N. Y.

ing properties by the customer ownership method should also be included. In the case of municipalities the question of what securities the municipality could issue against such property will have to depend on the laws of the State under which it will operate.

The Manual contains considerable subject matter as to formation of metropolitan water districts or small water districts taking supply from some larger plant. The subject is very well discussed and is an important one for there is a tendency for extending water mains in outlying sections, even beyond the best judgment of economy in taxes. Many subdivisions are being improved with light, water, sewers, pavements, etc., but have very little revenue immediately obtainable. In municipal plants funds can be provided by assessments against the property benefited, but where the territory is supplied by private water companies, the problem is still open for considerable discussion—especially where property is very often developed by agencies who market the property on sales commission and are interested only in placing it on the market with all improvements and ask the water company to finance the water supply.

The Manual does not contain any chapter under the subject "Accounting Systems" or manner of keeping the financial records in connection with water plants. This is a subject that has been more or less neglected by the Association. From time to time suggestions have been made by various members to take up this subject and even as to the formation of an Accountants' Section in the Association.

Mr. Fenkell of Detroit, in the discussions as to the manner of getting new members, stated that this was a very important thing in water works operation, especially in the case of cities where the personnel of the office might change, due to political conditions, and was a field for a new class of members for the Association.

The article should be prepared by expert accountants and suggestions offered by water works authorities as to the most advanced methods of providing a simple uniform accounting system which would "key in" with the plant operation, the financial requirements for financing water works properties and other regulating bodies.

The subject of Taxes has been very carefully covered and is a very serious problem in privately owned plants, due to the vast improvement work that is being carried on in various municipalities. Liberal allowance in determining rates should be made to cover taxes. The Manual shows the various methods employed in the various states

as to the levy of taxes, but this portion of the Manual in revision should be carefully checked for taxes are continually being increased.

Articles on betterments or new improvements would be next in order. Water rates should follow, as the proper rate should be determined through the information obtained as set forth in the foregoing subjects.

The chapter on Operating Practice should be included in the Distribution of Water, because most of the subjects in this chapter have bearing either on the furnishing of water or the laying of mains to supply the same. The cost of the maintenance and repair work and the handling of complaints and general water main extensions could be properly included under the chapter on distribution of water, correlated with the various subjects thereunder.

In the revision of the Manual, a new arrangement would be a decided improvement and should so present the subjects in logical order for reference by people interested in financing and operating water works property.

EDGAR K. WILSON:[4] Before entering on the section specifically assigned to me, I would like to echo the desire expressed at the December meeting of this Section for a volume more easily handled. It was suggested at that time that the Manual might be published in two or even three volumes. The desired result could be obtained without the added expense and trouble of two volumes by using the same paper as is used in Flinn, Weston & Bogert's "Water Works Handbook" or Hool and Johnson's "Concrete Engineer's Handbook." Each of these books, though containing about a hundred more pages than our Manual, is about one half inch thinner, being only $1\frac{1}{4}$ instead of $1\frac{3}{4}$ inches thick. A corresponding decrease in the Manual would make considerable difference in the ease of handling of the volume.

The general assignment for this discussion is the section entitled "Distribution of Water," including Chapters 13 to 19. Of this section Chapter 15 on "Pumping Station Practice" was discussed at the December, 1927, meeting of the New York Section, and it will therefore not be included at this time.

The first criticism of the assigned matter is that all through Chapter 13 we find scattered descriptions of various materials used in water

[4] Chief Engineer, The Pitometer Company, Engineers, New York, N. Y.

works construction. These might well be collected and put all together in a preliminary chapter. All these materials,—different kinds of pipe, protective coatings, joint materials, valves, and hydrants—are common to all pipe lines regardless of size; and a segregation of their discussion in a chapter by themselves would avoid the interpolation of such matter at various points throughout the chapter.

It is unfortunate and probably unintentional that the title of Chapter 13 is given as "Large Mains." Although this is the first subdivision of several which have their titles at the heads of their respective pages, it would seem preferable for the chapter heading to show the principal topic; which in this case would be the same as the heading of the whole section, "Distribution of Water," rather than to give the place of honor to whichever one of the four subdivisions might hold first place in arranging the subject matter.

Moreover, the term "Large Mains" is a misnomer in this connection, since the title is clearly meant to refer to the conduits which bring the water to the system rather than to any of the large mains which may form a part of the distribution system itself. Also, the term "Large Main" is entirely relative. In the case of a small community supply an 8 inch pipe running from a spring a mile or two up in the hills would be a "large main;" but the same sized pipe in a large city would be an insignificant part of the distribution system; while a 60 inch main or a Catskill Aqueduct might be required to perform the same service for the city which the 8 inch pipe performs for the village.

From the opening of the chapter it would seem as if considerable introductory matter had been eliminated at the last moment, without changing the opening paragraphs to correspond. The subject is, I believe, of sufficient importance to be formally introduced by a suitable paragraph.

Pages 290 to the last paragraph on page 293, discuss various kinds of pipes, etc., and would be much better placed in the proposed preliminary chapter. This would avoid the present long digression into matters equally pertinent to large and small mains which now interferes with the discussion of conduit or aqueduct mains.

On page 291 the short paragraph on pipe linings and coatings should also be placed in the preliminary chapter; but it would seem that this important matter should be expanded to include as much information as is available.

The remainder of the section on "Large Mains" tries to cover in a few words all features of such construction; and it is sufficiently complete, since every design for such structures is a separate problem, and the hints given are comprehensive enough to show the principle requirements. Mention might be made of the desirability of a measuring device on such lines.

From page 296 to page 305 the Manual discusses distribution systems, in a somewhat general way analyzing the requirements and citing authorities for the fundamental principles brought out. This appears to be about as complete as could be asked for in a work of this character. In this portion on page 304 under "Compounding System of Mains" reference is made to Freeman's graphical solution, 1892, 7, New England Water Works Association, 49. Since this valuable paper is out of print, and on account of its age is not readily available to many of our members, it might be well to reproduce the essential portions in the Manual. While it is understood that the Manual is not a textbook, it seems almost necessary to include certain material such as this which is not easily obtained elsewhere.

On page 313 the paragraph on "Pressure Records" might well be enlarged. The very valuable information obtained by recording pressure gauges is very often neglected and ignored. In too many cities, even of considerable size, the only gauges maintained are at the pumping station and perhaps at the water works yard; and their only apparent use is to establish an alibi when the fire department claims poor water pressure at a fire. It is not possible with the limited space available to give a full discussion of this subject at this time, but the advantages of proper observation and use of recording pressure gauges is obvious and some of these points should be added.

On page 317, the descriptions of kinds of pipe and jointing materials should be transferred to the proposed preliminary chapter.

It is a question as to how much space we can afford to give to such special work as described on pages 318 to 323 on "Pressure Tunnels." We may be sure that our editors have not used five pages of their space without giving careful thought to the matter. It would seem, however, in case of such highly occasional work, that the material might be compressed into considerably less space and still give the essential information. As is stated in the discussion of the matter on page 320, "A pressure tunnel is essentially a special structure and must be designed to meet the conditions of each site."

Chapter 14, on "Filtered Water Storage and Filter Capacity," appears to be ample without having so much matter as to be unwieldy.

Chapter 15, on "Pumping Station Practice" was discussed at the December meeting and no further comment is necessary.

Chapter 16 on "Services" is interesting and valuable. Without entering into arguments for or against any particular material or method for service pipes, the editors have presented the advantages and disadvantages of each in an orderly, concise manner. In the section on "Thawing Frozen Services and Hydrants" it might be well to insert a diagram showing the electrical connections for this work. Such information is often requested in the water works publications, and if it could be in the Manual, it would be very convenient.

"Chapter 17 on "Plumbing in Relation to Water Supply" is complete enough for the purpose evidently intended, namely, to give an idea of what happens to the water when it passes into the houses. The bibliography at the close of the chapter offers a chance for anyone to get further information along these lines without burdening the volume.

Chapter 18 is devoted to the two very important subjects of Corrosion and Electrolysis. Both of these seem to be treated very fully and it is hoped that a discussion on them may be given by some of our members who are more fully qualified in these lines.

On page 414 is a bibliography on corrosion, which could be made of a great deal more value by giving the complete list rather than referring to the previously published bibliographies, which would first have to be located and culled over before further researches could be made. Since the bibliographies referred to are on metals in general, the selection of these pertaining to water works should be made for the Manual.

No bibliography is presented with the section on electrolysis, and it seems a rather unfortunate omission.

The chapter on Water Consumption, which closes this section of the Manual is one very close to the hearts of every water works man. I wonder, since the consumption data are so important in the design of water works, why it has been placed in the last position instead of at the beginning of the section which would seem the more natural place for it. Perhaps some of the sub-divisions of the chapter might be separated from the portions on water consumption and placed in a later chapter.

In closing, I would say that we have, in general, a very valuable Manual, which can be improved by coöperation of those who are in position to use it and who will give it good constructive criticism.

J. A. WADE:[5] It is the somewhat unpleasant duty of the members assembled today to offer criticism of the work of members of this association which has involved considerable hard effort and sacrifice of personal time. We cannot spend a great deal of time today in commenting on the many excellent features of the text. The object of this meeting is to develop ideas for the improvement and strengthening of the Manual. Being as it is primarily the manual of a given association, it must of necessity be of value to the members of that association. The association is made up largely of water works owners or executives and operating managers and engineers. It is not probable that all the material in the text can be of value to all these classes, but certainly a matter which is not of value to some one of these classes can hardly be included in a text which is bound to be expensive in any case.

In looking at Chapter 13, the thing that struck me first-off was the large amount of space given to a discussion of pressure conduits and tunnels and separate fire protection system. These two subjects occupy one-quarter of the entire chapter. Comparatively few engineers are actively concerned with either one of these matters. Separate fire protection is largely a matter for larger municipalities and pressure tunnels occur in only a few instances. This matter could be condensed without injuring the general character of the book. On the other hand, the carrying capacity of the various types of pipe is treated altogether too briefly and some materials received very scant attention. In recent years concrete pipe and cement lined pipe, also welded steel pipe in larger sizes, have become increasingly important. The matter of coefficients to use for the different materials and different conditions of pipe could very well be discussed at considerable length, as they are the matters which determine design of new systems or extensions to old. There is a division of material when Chapter 13 contains a discussion of consumption and fire demands. This would apparently belong in the chapter on water consumption. I might point out that the table of the requirements of the National Board of Fire Underwriters is printed in the text three times,—once in this chapter, once in the fire protection chapter, and once in the appendix.

A matter which could be discussed at a considerably greater length is the matter of distribution storage. In designing a plant or

[5] Engineer, The Federal Water Service Corporation, New York, N. Y.

any of its principal features, two controlling questions are, the average demand and the fluctuation from the average, and the amount of distribution storage which exists, or which will be provided. Chapter 14 gives a very clear description of the relation of distribution storage to filter plant capacity, but the effect is exactly as important and far reaching in the design of transmission and distribution mains and in the design of the pumping station. These matters, so far as the speaker knows, are not discussed in the text. I would suggest a separate chapter on distribution storage with full discussion of its relation to the design or required capacity of mains, filters and pumping stations; also various types of reservoir, materials, methods of construction, etc. The discussion of relation to filter capacity is excellent. The method of giving statistics of existing installations in various municipalities I think could be very well extended to the treatment of other subjects.

Chapter 19 on the consumption could be extended somewhat with a discussion of demands for maximum season, maximum week, day, peak hour, etc. with some statistics of conditions as they have been found in cities of various sizes. I agree with Mr. Wilson as to the location of this chapter. It is certainly the first thing that has to be determined before any part of the plant can be designed and it would seem that it should belong in the beginning of the chapter.

I think a great deal could be added to the value of the book if there were a bibliography at the end of each chapter. There are some references, but not easy to find and these could well be extended. There should also be a great many cross references. The chapter on distribution contains the only discussion so far as I know of the location and spacing of fire hydrants. That is a matter of fire protection not of distribution. Cross references in the chapter on distribution as to where a discussion of fire hydrants can be found would be sufficient.

Reeves J. Newsom:[6] As it is the purpose of this manual to act as a handbook to operators, it should contain, where practicable, certain tables and diagrams and rules that will enable the operator to find there the solution to his ordinary problems. In connection with my work the last year and a half, I have had occasion to examine and

[6] Vice-President, The Community Water Service Company, New York, N. Y.

analyze the operation of many water works plants, and to observe what seemed to be the common troubles and faults of those plants and their methods of operation. I found that there are two things which are extremely noticeable about which the operators seem to be doing a lot of guessing or else are following customs that have obtained for a great many years without any apparent reason.

I refer to the sizing of service pipes and the methods of testing water meters. You find all sorts of conditions in various plants. A plant will adopt sometime in its history a certain size of service for certain classes of consumers and then will apply that rule without respect to the variation in pressures in the various parts of the system and differences in demand from consumers of apparently the same size, but whose actual requirements inside their properties may vary considerably and also, without giving much thought to the length of the service.

I find that the methods of testing water meters in many plants are far from being accurate. A very common method of testing water meters is to test them all at full stream. Of course, a full stream condition on the testing bench means that water is discharging with practically no back pressure and the amount of water passing through a $\frac{5}{8}$ inch meter may be 23 or 24 gallons per minute. You cannot get any such condition as that when the meter is in the house where the various sizes of pipes and openings in the building create back pressure, and so a test of a water meter at such a stream as that means nothing as compared to the actual conditions in operation. As a matter of fact, a stream of $\frac{1}{8}$ inch in diameter is an enormous amount of water compared to what can be drawn from fixtures in a house. In some cases the full stream test and no other is used, or the small stream test may be no smaller than $\frac{1}{8}$ inch. When a meter is tested under such condition and then put back into service the results are not comparable.

It seems advisable for the Manual to contain, in the first place, with regard to services, a table which would indicate the proper size of service line, depending upon the demand that is going to be required. There we are very short of information. The average water works man does a lot of guessing for customers. I do not think very much work has ever been done setting forth the actual demand in gallons per minute that results from using a toilet, bathtub, faucet or various combinations of these things. Now there is coming into use the

flushometer which creates an entirely new set of conditions as it demands so much water in a short space of time.

If the Manual contained some information about the demand in gallons per minute resulting from various combinations of fixtures, the operator would be able to decide what particular demand in gallons per minute he should design his service for. Then, the table on services should vary not only with the demand but also with the operating pressure. If the property sits well back from the street, the size of service line under a given demand and pressure should be different than if the building is out at the street line.

There should be in the Manual a table which would indicate to the water works operator the sizes of the openings he should use in testing his meters, which sizes of openings would vary with the pressure. It should set forth the various rates in gallons per minute at which he should test his meters and then give the size of openings that correspond, as the pressure varies. It is difficult for the average operator to determine just what size of opening should go with the rate he wants. Such tables should be of great help. They would have to be used with caution and notations should be made in the manual that operators are not to attempt to apply them without understanding fully that they are limited only to average conditions.

J. Walter Ackerman:[7] Mr. Huy spoke about taxation. There was some question in my mind relative to the advisability of having that section in there for this reason. Your laws are constantly changing. Every session of the legislature is full of changes. So unless it is a very late publication, if you attempt to follow it, you find you are in a morass and misled by those facts. The book is intended to cover the country and gives all the laws of the different states. I am a little doubtful if I would recommend the continuance of trying to give the laws in all the states relative to taxation, due to the fact that they are constantly changing.

I quite agree with a number of the speakers who have mentioned the fact that after each section the bibliography should be given. If a man is seeking information, he gets some of it, but he wants to pursue the matter further. Give him the opportunity of the bibliography right before his eyes. I am quite agreeable to Mr. Wilson's statement that we might make the book smaller so that it would not

[7] City Manager, Watertown, N. Y.

be quite so cumbersome. It seems a crime to me to waste all the space in the book for the table of standard sizes of water pipes when you have them by the hundreds all over your offices. All pipe companies are furnishing you with that, so why have it there, although, as Mr. Huy says, you want it all in one book. There is not a water works man that does not have a number of those tables already in his office where he can lay his hands on them.

A. C. HUTSON:[8] The Chapter on Fire Protection goes into some detail as to why the American fire rates are higher than in other places. I presume the main thought was that we wanted to make the water works men realize that fire protection was a very vital item in this country. I am going to cover that in a slightly different way to emphasize the burden that is laid on water companies and water departments. There has been a great deal of talk in the past years on the question of carelessness. The American public has been "lambasted". The thought seems to be that we start fires just for the fun of starting them. The question was put up to me two years ago and I started digging into a few records. One of the things that stared me in the face was that throughout most of our cities you were getting 65 per cent of the total fire loss in from one to two per cent of the total number of fires. In other words, you have a great many small fires that do not amount to much, but a very few large fires that run into thousands of dollars.

In the City of Boston we found that out of about 4500 fires there were 60 fires of $10,000 or more and those 60 fires, which is a little over 1 per cent, gave you 65 per cent of the total loss. There are several reasons for that. The first is the delay in discovery of the fire. You ask the fire chief and he will tell you that such a fire had the building well involved when he arrived. It is not so much the delay in getting to the fire. Another feature of prime importance is the structural condition of the building. Many of our structures were built years ago without a thought of fire protection, when material was cheap and when the owner had very little money to put into the building. The result was that he built his buildings to burn without realizing it.

As you walk around the streets of different cities you find that most

[8] Assistant Chief Engineer, The National Board of Fire Underwriters, New York, N. Y.

of the stores have a perfectly beautiful flue right through the center or at one or both ends. That flue is caused by an unprotected stairway or elevator shaft. Even in some of our so-called modern fire proof buildings, you will find that condition. Fire starting on lower floors immediately mushrooms on an upper floor unless the fire department gets there quickly.

The matter of large areas is also a very important one to the fire chief and American public. When you have buildings of excessive size you cannot throw a fire stream from the outside into that building and wet all parts. A building is very often sub-divided by partitions or some other obstruction is in there to keep the fire department from getting lines into the center of the building.

The hazard of the contents adds to the fire burden. When you have a building occupied by a man making celluloid buttons you will get a fire too quick for any ordinary department to extinguish.

There are remedial provisions for all of these features. The first would be some means of discovering that fire. We have automatic fire alarm systems by which the fire is discovered and notification sent to the fire department. You also have watchmen with signal devices or fire alarms outside of buildings. You have improved construction. You can cut up your areas, you can separate your hazardous occupants. Probably the best means of protecting buildings today is automatic sprinklers. I am not selling them, but talking as an engineer. They do two things, if properly put in. They call the fire department and also extinguish the fire or hold it in check. It is in connection with the automatic sprinkler system that the water works either private or public must come in, because a water works system is the best means of furnishing a supply to an automatic sprinkler system. It is more dependable, it has greater capacity and, therefore, it serves the purpose of a supply to a sprinkler system better than any other means. It is necessary, therefore, for the water works interests to do all they can to aid in the installation of automatic sprinklers.

Only a few months ago I had to go to Fall River and report on a conflagration there. That was due entirely to a very large area mill building in which originally there were automatic sprinklers, but which had been removed. In addition, the wreckers had taken windows and doors out and you had an ideal situation for fire. You can take almost any city and find a similar condition.

I am not going to burden you with a long talk on fire protection, but

I was asked that I criticise or comment on the Manual or other parts where we felt the fire protection had not been taken care of as well as they ought to have been. I want to agree with Mr. Wade in the ideas that storage has not been covered as it should be in the Manual. We consider storage the most important feature. At the present time the Manual covers storage under filter plant systems only. It does not cover it in connection with ground water supply. We have found that ground water supply is seldom developed to a point where it can furnish fire protection from the source of supply.

I do not remember a single city that we have inspected which had a ground water supply, but that we recommended an elevated storage on the distribution system or suction storage for the pumps. I think that should be brought out in a section dealing with ground water. Cross reference to a general chapter on storage would be best. In general, we feel fairly safe if there is from five to ten hours' fire supply in storage reservoirs over and above the peak hour demand. Five for the smaller cities and ten for the larger. This question of storage also is important in connection with pumps, boilers, supply mains and, in fact, from our standpoint it affects almost every phase of the fire protection furnished to a city.

We would like to see the storage in every case at the opposite side of the city from the source of supply. That gives a duplication. I have in mind a place in Ohio that had hills all around, but when they built the reservoir they built it just up the hill from the pumping station and both are two miles from the city and the entire supply from reservoir or station must go through the same supply main. The result is that they have been cut out three or four times in the last few years. Now they are contemplating a reservoir on the opposite side of the town from the pumping station with a main of good size to give a proper delivery.

It is very important in connection with storage that proper consideration be given to the size of the main leading from the point of storage because it should deliver at a large rate, preferably a rate equal to the fire demand at least. Then your supply works could furnish a normal domestic rate and your storage could furnish the fire rate.

In connection with this amount of storage, it will probably interest you to know that in Fall River the peak demand was kept up for ten or twelve hours and that demand ran 10,000 or 12,000 gallons a minute over and above the domestic rate, which gives you some

idea of the amount of water that is necessary to furnish protection to our American cities when they have a fire and can call in enough fire apparatus. It is unfortunate, but I think true, that the water works must stand a burden rather out of proportion to what should be placed upon it. For instance, in Fall River 33 municipalities sent apparatus. That meant that approximately 40 pumping engines were operating. If the water works had fallen down the papers would have made a great deal of it. The blame would have been placed on the water works. It is not fair because the blame was due to the condition of the buildings and not to either the fire department or the water supply. The water works is called upon to furnish all the water the fire department may need and sometimes all the water the fire department and outside aid may call for.

The chapter on pumps is rather weak from the standpoint of fire protection. There is nothing in that chapter on the character of pumping station. We feel of course that the pumping stations and all buildings on which supply depends should be fire proof throughout. We know of cases where a building has been fire proof, except in the roof and a fire has started there, probably by lightning, and the roof has fallen in and put the plant out of operation. We do not feel that sufficient attention has been placed to the need of reserve pumps and boilers. It has been our belief for a number of years that for a city to be in a fully reliable condition you should be able to put two of your larger pumps out of service and still be able to have maximum domestic service and fire protection. Every machine must be overhauled at intervals and during that time you must of course use an older pump in service to take its place. There is greater probability of accident occurring at that time. So for perfect dependability we ask for a sufficient number of pumps for two to be out at the same time and still be able to furnish fire protection.

A few days ago, in discussing this question, one of the consulting engineers told us our demand was more or less foolish and there was not a system in the country that could meet that requirement. We could mention nearly 100 off-hand that can meet that requirement. That duplication should include steam lines, boiler feed pumps, boilers, suction and discharge lines and other major parts of a plant. There should be no point in the system where a single break can seriously cripple your fire protection. We do not believe the repair of a single gate valve should cripple your water system.

A very interesting article by Dennett and Swan covering elec-

trical equipment from this standpoint was printed in the Journal of the New England Water Works Association. I suggest that, in reviewing this subject, the editors read that article to cover the points brought up in it.

In laying out large supply mains there should be enough gate valves so that you can cut out a portion of the line. They should be cross connected where possible, but the cross connection should have a double gate on it, otherwise the breakage of that single gate would put both lines out. There are a number carrying out that principle at the present time.

We do not pay much attention to calculations in our study of distribution systems. When I started this work that was my first job. I calculated the carrying capacity and when I finished I had to acknowledge I would not know whether I was right or not. I do not believe any man can take a system and do very much calculation as to the carrying capacity of that system. We think it much more exact either to have measuring devices in your principal mains or to run fire flow tests. There have been a number of articles read before this Association on fire flow tests. They are the best means of determining where you should strengthen your system. Personally, I would leave out most of the part of the Manual that talks about calculations because I do not think many of you will ever use it. Any water system should be laid out more or less in advance. There should be more or less general scheme of improvement. This does not mean that all pipe sizes should be determined in advance, because I do not believe it is possible. Large mains should extend to the center of largest demands. In general, the centers of larger demands are the mercantile and manufacturing districts. In this connection the idea that better consumption records should be kept is a good one, not only with reference to total consumption and various fluctuations, but records as to demands in various sections of the city. I agree with Mr. Wade that recording pressure gauges should be used throughout a system. Kansas City has 8 or 10 recording pressure gauges around the city. From these gauges they plot the average drop in pressure and the peak drop and by doing this they can determine approximately where they should lay their large mains.

Our suggestion would be to lay out a distribution system with 12 or 16 inch mains forming rectangles about 3,000 feet apart and lay these out irrespective of your principal feeders. Then as your pressures start dropping to what you thought was a fair or a reason-

able drop, run a large main, even though it might parallel a 16 inch, into the section needing this additional supply.

I have noticed recently a tendency on the part of water works superintendents to try to belt line a city with large main on the outer edges of the system. Those mains running in the outer edges of the system do not add much to the fire protection of a municipality. A short time ago the engineers of a large western water system were in the office and they had in mind a 42 inch main which was going to be run through a section now largely vacant. They were running this main with the idea that they would have a population of 20,000 in that section, but this 42 inch main did not deliver any water to the rest of the city. I think we finally convinced them that they would be better off to lay a 24 inch main now and later another 24 inch quite a distance away.

A point not covered by the Manual is that of records. We have requests every once in a while from superintendents and others for a good set of records. We do not like to set ourselves up as knowing everything so we do not try to furnish records. But I believe a chapter in the Manual in which sample records are given would be of great value. This should include records of gate valves, hydrants, consumption, pressure, pipe laid, practically all of the work carried on. I know that some of our friends who recently have taken over some new water systems would have been tickled if there had been a chapter on records available a few years ago and the superintendents of some of these plants had lived up to it. So we would like to see something covering records.

I do not know of any other particular section at this time that I want to cover. The Manual is good. I think everyone who has anything to do with water works should have that Manual and read it, if nothing more than for the appendix on fire protection requirements. All of your American cities today are graded on that schedule. It is more or less of an engineering proposition and I think it would be of great value to all superintendents if they applied the schedule to the best of their ability to their own system.

PROGRESS REPORT OF AMERICAN ENGINEERING STANDARDS COMMITTEE ON MANHOLE FRAMES AND COVERS[1]

During the past year, the Sub-Committee appointed to study the details of manhole frames and covers for use on sewer, water, gas, steam and air, has been active under the leadership of Mr. William W. Brush, a member of this Association. The standard designs of a number of cities and public service corporations have been studied and tentative standards prepared for discussion by the members of the Sub-Committee. The Chairman now has under preparation a report to the main committee outlining certain standard types of manholes frames and covers suitable for use in the several classes of work mentioned above. Such standards when finally approved will, it is believed, be of value in reducing the numbers of such designs now being made and will provide standard designs that can be generally used where no previous standards existed.

In view of the state of the work, this report can only be considered as a progress report.

Respectfully submitted,

FRANK A. MARSTON,[2]
Representative of the American Water Works Association on Sectional Committee of American Engineering Standards Committee.

[1] Presented before the San Francisco Convention, June 15, 1928.

[2] Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

PROGRESS REPORT OF THE COMMITTEE ON STANDARD FORM OF CONTRACT[1]

The Committee on Standard Form of Contract has held no meeting during the past year. However, the committee has been in touch with what is going on and has made inquiries from time to time regarding the use of the standard form of construction contract.

There is evidence of a marked increase in the use of this form. Many engineers of long experience in drafting contracts and specifications are sold to the standard form of construction contract as a guide or are using the form exclusively. It is apparent that these forms are meeting a long felt need and particularly in the case of small contracts are serving a very valuable purpose in helping those who have not had extended experience in drafting contracts to prepare an intelligent and practical form.

In the case of construction contracts it is not possible, as in the case of building contracts, to have a form which is the actual contract document, because the engineering form of construction contract has to cover so many differing conditions and types of construction, such as sewers, tunnels, pipes, buildings, machinery, etc., and the best that can be done at present with the engineering contract is to establish a guide on which to base the form of contract.

There is a tendency to increase the use of the arbitration clause, but it is probable that growth along this line will be slow, because the legal departments of municipalities will be reluctant to allow such a clause to be written into the construction contracts. However, it is believed that substantial progress is being made and it may be expected that the form will grow in favor and be used more and more each year.

Respectfully submitted,

J. Waldo Smith,[2]
Chairman.

[1]Presented before the San Francisco Convention, June 15, 1928.
[2]Consulting Engineer, New York, N. Y.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Etiology and Prophylaxis of Endemic Goiter. F. M. Messerli. Revue Médical de La Suisse Romande, Lausanne, 48: March 25, 1928. Abstracted in Journal American Medical Association, 90: 1753, May 26, 1928. Messerli, 1911, showed that drinking water in regions of endemic goiter practically always came from shallow wells and was always infected. In 1914 he produced goiter in white rats by causing them to drink water from a part of Switzerland in which goiter was endemic. In 1923–1924 he produced the same condition in white rats by giving them water which had first been boiled and then passed over human feces. Infected water, however, cannot be considered as the only etiologic factor. Intestinal stasis also plays a rôle. "Thyroidal constipation" is of frequent occurrence in goiter patients and disappears under treatment of the goiter. An effective prophylaxis of endemic goiter necessitates two types of measures: (1) general measures which improve the hygiene and particularly the drinking water of the people in the endemic regions; (2) measures such as the iodine treatment, which tend to effect the prevention of goiter on a grand scale.—*John H. O'Neill.*

Activities of Plankton in the Natural Purification of Polluted Water. W. C. Purdy. American Journal of Public Health, 18: 4, 468–475, April, 1928. A summary of the results of the plankton studies made by the United States Public Health Service on the Potomac, Ohio, and Illinois rivers. Bacterial pollution was shown to decrease as pollutional forms of plankton increased in number, this increase being followed again by a decrease in the number of these forms. Laboratory studies indicate that the pollutional forms of plankton consume bacteria as food and thus the above relation is explained as follows: Sewage pollution introduces large numbers of bacteria into streams and ciliated protozoa increase in number as their food supply becomes more plentiful. The exhaustion of this food supply leads to the subsequent death of these so-called pollutional forms of plankton. The opinion is expressed that the liberation of oxygen by photosynthesis and the churning action of

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

very numerous motile organisms are important factors in the oxidation of organic matter in polluted streams.—*Chas. R. Cox.*

Endemic Goiter and Public Health. O. D. Kimball. American Journal of Public Health, 18: 5, 587–601, May, 1928. This is a short history of the medical aspects of goiter and its prevention by the use of iodized salt or medical treatment. No mention is made of the periodic addition of sodium iodide to public water supplies of several cities in this country, to prevent goiter among the consumers of water.—*Chas. R. Cox.*

Health Policies for Control of Public Water Supplies. American Journal of Public Health, 18: 4, 459–467, April, 1928. A report of the Committee upon Water Supply of the Engineering Section, American Public Health Association. The state control of public water supplies is discussed in detail. Coöperation between state and waterworks authorities is advocated. Sanitary surveys, the stimulation of technical control of water purification, the insistence upon equipment to give uninterrupted service, a program of harmonizing the various legitimate uses of watersheds, and the advocacy of local and state laws prohibiting cross-connections between public and private water supplies, except when the private supplies are potable, with the emphasis upon education rather than arbitrary enforcement of these laws are the essential features of this report.—*Chas. R. Cox.*

The Residual Germicidal Action of Water Treated with Ultra-Violet Light. John F. Norton. American Journal of Public Health, 18: 4, 476–479, April, 1928. Laboratory tests at the University of Chicago indicate that the exposure of Chicago tap water to ultra-violet rays does not impart any lasting germicidal property to the water; nevertheless, a slight and transitory germicidal property was imparted to water which was strongly radiated. The experiments were carefully controlled, and they are to be extended to study the mechanism of the transitory germicidal property.—*Chas. R. Cox.*

Water Works Surveys, Old and New. Lewis A. Quigley. American City, 38: 4, 111, April, 1928. A water-waste survey of Forth Worth, Texas, disclosed the loss of 915,000 gallons per day, valued at about $16,000 per year. Joint leaks, found to be responsible for 48 per cent of the leakage, appeared to be due to the fact that the joints were calked before the lead had cooled sufficiently.—*Chas. R. Cox.*

Advertising Water-Works. Pearl D. Fife. American City, 38: 4, 121–122, April, 1928. An illustration of the value of an educational campaign to instruct consumers in the basic facts of the water supply system of Kirksville, Mo.—*Chas. R. Cox.*

Clarification of the Catskill Water Supply of the City of New York by Coagulation and Sedimentation. W. W. Brush. Jour. New Engl. Water Works Assoc., 42: 1, 65, March, 1928. Two water-sheds supply water for the Catskill System; both contain numerous clay banks. Hence flood-flow occasions

considerable turbidity. Area of Esopus watershed is 257 square miles. Ashokan Reservoir is divided into two basins having capacities, respectively, of 48,300 and 82,200 million gallons. Kensico Reservoir has available capacity of 30,000 million gallons. Time required for water to pass through Kensico Reservoir is two weeks; after which an aqueduct 14 miles long conducts it to the Hillview distribution reservoir of 900 million gallons capacity just north of city line. Rainfall of November 15–16, 1926, caused the heaviest run-off recorded in twenty years. Water became brick red in color with a turbidity of 120 p.p.m. The clay particles were about one-half the size of bacteria and were in constant motion. It was evident that water in Ashokan Reservoir would not clarify by sedimentation for several months and that coagulation treatment was necessary. One grain of alum per gallon produced a satisfactory floc and reduced the turbidity from 100 to 1 p.p.m. in twenty-four hours. Samples tested were allowed to stand for twenty-four hours and if water then clear, results were considered satisfactory. As turbidity declined below 50 p.p.m. dosage of alum was reduced successively to 0.9, 0.8, and finally to 0.5 grains per gallon. Treatment stopped on May 28, 1927. Maximum treatment required 44 tons of alum and 22 tons of soda ash per twenty-four hours. Catskill water is very soft and slightly acid. Addition of alum increased the acidity. Soda ash was not available until December 21, 1926. It was added at rate of 0.5 grains per gallon, whereupon the pH which had dropped from a range of 6.3 to 6.7 before use of soda ash rose again to 6.5 in February and 7.0 in April. Soda ash was dumped from a bag by one man at intervals of about two minutes. By this simple method a thorough mixture with the water resulted before Pleasantville plant, 75 miles away, was reached. Turbidity in Ashokan Reservoir remained high throughout the winter and early spring. Final clearing up took place during last two weeks in May. There was no indication that the clay and alum would again come into suspension in the water. Diagrams and tables are given.—*Carl Speer, Jr.*

What Every Engineer and Water-Works Superintendent Should Know About Chlorination. Richard V. Donnelly. Jour. New Engl. Water Works Assoc., 42: 1, 79, March, 1928. Liquid chlorine is supplied commercially in steel cylinders sized to contain net weights of 100 and 150 pounds and of 1 ton; the last for large users. Cylinders for water works purposes are kept especially clean. Liquid chlorine becomes gasified upon reducing pressure, as happens by means of valve of cylinder. The gas passes to chlorine regulator. Functions of regulator are: (1) to reduce chlorine pressure, (2) to measure flow of chlorine under reduced pressure, (3) to maintain a constant drop in pressure across a measuring orifice, (4) to maintain a constant back pressure on measuring orifice, and (5) to provide means of altering rate of chlorine flow. With the "solution-feed" type of chlorinator, the chlorine gas is first mixed with a small flow of water and this mixture then applied to water to be chlorinated. Solution feed apparatus requires a water supply under at least 20 pounds per square inch pressure. Fifty gallons of water should be available for each pound of chlorine used. Pressure at point of application is not more than one-third the pressure of the water supply available to operate the machine. Direct-feed apparatus does not require any water supply. Pres-

sure in the chlorine cylinders with direct feed apparatus is sufficient to overcome pressures at the point of application up to 25 or 30 pounds per square inch. Direct feed apparatus is generally more simple to operate and install and somewhat less expensive. Special adaptabilities of the two types are illustrated by several examples.

Equipment specifications should include: (1) proper protection from the elements of chlorinating apparatus, (2) temperature of 45°F. or above, (3) safe draft of 50 pounds of chlorine per day per cylinder, (4) temperature of cylinders not to exceed that of chlorinator. Common troubles with chlorinators: (1) leakage of chlorine, (2) corrosion by moist chlorine, (3) clogging of tank connections, due to impurity of chlorine, or in the machine, due to corrosion. New uses of chlorine: (1) for control of algae; especially those not readily destroyed by copper sulphate, (2) ammonia and chlorine are being used in England and United States to prevent chloro-phenol tastes, (3) newly laid water mains are often sterilized with chlorine just before putting them into use, (4) used in several Florida towns to remove sulphur tastes, and (5) disinfection of sewage.—*Carl Speer, Jr.*

Iron-Removal Plant for Amesbury, Mass. George Sampson. Jour. New Engl. Water Works Assoc. 42: 1, 53, March, 1928. The population is about 12,000: driven wells are the main source of supply. Sanitary quality of water is excellent, but iron content increased until finally up to 58 pounds of iron per million gallons of water was being delivered to the distribution system. Capacity of iron-removal plant is nominally 1.5 m.g.d., but it is expected that a satisfactory effluent will still be obtained at the rate of 2 m.g.d. General arrangement of plant with its parts is shown in diagram. Parts and processes include (1) aëration, (2) tricklers, (3) subsiding basins, (4) two filters (slow sand type). Final removal of iron takes place near surface of sand in the filter. The film of combined iron and organic matter is removed by scraping or raking. The latter is less expensive and not wasteful of sand. (5) filtered-water basin. Total cost about $85,000. Pumping equipment required low-lift pumping of the unfiltered water from the driven-well system to aërators; high-lift system pumps the filtered water from storage basin to distribution system.—*Carl Speer, Jr.*

Relining Payson Park Reservoir, Cambridge Water Works. Lewis M. Hastings. Jour. New Engl. Water Works Assoc., 42: 1, 45, March, 1928. Population of Cambridge is 125,000. Average consumption is about 12 m.g.d. The water, obtained from two sources (Fresh Pond and the watershed of Stoney Brook), is filtered, aërated, sterilized, passed through pumping station to Payson Park reservoir, and thence through various distributing pipes to the city. The reservoir has a surface area of 7.4 acres, and a capacity of 43 million gallons. Average depth of water is 20 feet. Enclosing embankments are of earth obtained from excavations and are lined with concrete. Floor is of concrete; a heavy partition wall (dividing it into two equal basins) is of granite; the inner slopes are protected by slope paving. Because of poor initial construction leaks were very bad. For lining the basin gunite not less than 2 inches thick at any point reinforced in the center with wire mesh was used. The base for the gunite lining was of several different types: (1) con-

crete slab floor base, (2) granite paved slopes, (3) sides of the partitition wall. In (2) and (3) the average thickness was more than 2 inches. Gunite consisted of one part Portland cement and 2½ parts of sand; to be mixed dry and water added at nozzle of gun as required. Tests were applied to insure proper thickness. Contract price for entire work was $131,576.—*Carl Speer, Jr.*

An Important Water Company Decision. LEO T. PARKER. Water Works Eng., 81: 4, 203, February 15, 1928. Water company entered into a contract with the city to supply wholesome water to the municipal administration for public buildings, street sprinkling, and for the extinguishing of fires and to the inhabitants, for domestic purposes. The company was to maintain in proper working order all the fire hydrants, but at the time of fires, or inspection, the city, through its fire department had exclusive control of all hydrants. A building caught fire. The fire department of the city was not negligent in its efforts to extinguish the fire, but failed, owing, it claimed, to the water company's neglect to furnish sufficient quantity of water with adequate pressure to stay, suppress, or extinguish the fire. The owner of the building sued the water company for $46,477. The Court held the water company not liable and said, "In our view, it was not intended that this defendant (water company) should assume a liability to protect property owners against fire loss. We think that this contract in respect to extinguishing fires was a city contract, primarily made for its benefit, and not for the benefit of a property owner of the city."—*Carl Speer, Jr.*

Reservoir Built Below Water Level. T. R. HAZELTINE. Water Works Eng., 81: 4, 199, February 15, 1928. Elkhart, Ind., has population of 40,000. Old source of water supply, which was privately owned, became inadequate; city purchased plant and made necessary improvements. Construction of reservoir is of interest because of method used in combating ground water and scientific control of concrete on so small a job. Reservoir is 111 feet square and about 15 feet deep. Floor and roof are of flat slab construction, supported by columns on 15-foot centers. Normal ground water level is about 12 feet above the reservoir bottom. Reservoir was designed to serve as a clear well for a future filter plant. Two motor driven centrifugal pumps, one 8-inch, capable of handling 1600 g.p.m. and the other, 6-inch, capable of handling 1200 g.p.m., were used to pump out the water. The floor of reservoir was poured continuously and required one hundred seventy-five hours. Concrete was spouted into place from mixers on the banks. Walls were poured in four sections, each section being composed of one corner and one-half of the adjacent sides. Each section made a day's pour for the mixers. Keyways were left in all construction joints throughout the structure. Horizontal joints were slushed with 1:1 mortar before pouring concrete on them. Two pounds of celite per bag of cement was used in all concrete in floor and walls. Celite increased the slump, flowability, workability, and homogeneity of the mix, and did not decrease the strength of the concrete. When reservoir was filled with water and allowed to stand for twenty-four hours a ⅜-inch drop in water level occurred. Approximately 1240 yards concrete and 220,000 pounds reinforcing steel were used.—*Carl Speer, Jr.*

When Is an Increase in Rates Justified? R. E. McDonnell. Water Works Eng., 81: 7, 401, March 28, 1928. Water standards have been raised. With our knowledge of water-borne bacteria, it is unsafe, unbusinesslike, and unpopular to offer anybody a drink of water unless it is pure, clear, sparkling, and palatable. Since experience has demonstrated that 65 per cent of all water-borne disease is traceable to impure water supplies, we begin to appreciate the value of pure water. Our tastes have become educated and our standard of living raised. Water in addition to being pure, must be soft, clear, sparkling, free from iron or minerals, and without odors or taste. The furnishing of water that meets all these requirements calls for the highest technical-trained skill available, both in design and operation. The investment necessary to obtain pure, sparkling, soft water is many times greater than it was a few years ago. With this increasingly high investment, there should be correspondingly increasing rates. In the 6000 water plants in the United States serving over 60 million people there have been only a comparatively few plants that have met the improved service with an increase in rates. The water plants, privately owned in most cases, have sought, through courts and commissions, a raise of rates commensurate with the increased cost, but hundreds of municipal plants are still struggling to meet the demand for better service. Water works men have not placed all the facts squarely before the communities served. The need of a rate increase is not usually apparent until the demand comes for filtered water instead of settled water, covered reservoirs instead of open reservoirs, closed water conduits instead of open canals, softened water instead of hard water, water with odors and tastes and injurious minerals removed, better pressures, extension of mains, replacement of inadequate distribution systems.—*Carl Speer, Jr.*

Municipal Water Analyses. E. L. Filby. Florida Health Notes, 20: 2, 26, February, 1928. Lists 89 cities in Florida which own shipping cases and regularly each month submit samples of water to State Board of Health for analysis Sole cost to city for this service is that of the box to start with ($14.50) and about $1.50 per month expressage. Bottled waters prepared for market in Florida or shipped into state are examined every two months. —*G. C. Houser.*

Regulations Adopted by State Board of Health. Monthly Bulletin, Indiana State Board of Health, 31: 2, 19, February, 1928. On January 18, 1928, the Board adopted rules requiring that plans and specifications for the construction of any public water supply or sewerage facilities, including water purification or treatment works and sewage treatment or disposal works, and plans for material changes in existing facilities or works shall be submitted to the Board for approval as to sanitary features before being adopted.—*G. C. Houser.*

Polluted Water Causes Epidemic. Illinois Health News, 14: 2, 42, February, 1928. An outbreak of intestinal disorder in Marseilles, involving at least 54 cases, started on January 7, 1928. Public water supply flows from artesian wells into storage reservoir. Upon draining the latter, a hole was discovered

in bottom of reservoir wall, which adjoins a power race carrying highly polluted water of Illinois River. Just before epidemic, an ice jam in river had caused water to rise above normal in race, thus causing inflow of river water into reservoir.—*G. C. Houser.*

Sewage Plant Effluent as Drinking Water. Public Health News (N. J. Dept. of Health), 13: 2–3, 64, January–February, 1928. On a recent visit to a sewage treatment plant in northern New Jersey it was noticed that it is a common practice for employees at the plant to drink the effluent as discharged from the sewage filter beds. It was also indicated that it is quite common for nearby residents to collect water from the same source for drinking purposes. State Department of Health has recommended that local board of health move for the prevention of this practice.—*G. C. Houser.*

Rural Sanitation with Special Reference to Water Supply. X. H. Goodnough. The Commonhealth (Mass. Dept. of Public Health), 15: 1, 3, January–February–March, 1928. Where it is impracticable to dispose of household sewage at a lower level than water in the well, it is important to locate places of sewage disposal at least 250 feet from source of water supply. In swampy regions it is best to locate the well on the upland 50 to 100 feet from swamp. Pipes lined with tin or with cement are satisfactory for conveying drinking water when the water is found to be corrosive.—*G. C. Houser.*

North Bergen Township Installs Sewage Disposal Plant. Public Health News (N. J. Dept. of Health), 13: 4–5, 106, March–April, 1928. Prosecutions against township of North Bergen, N. J., resulted in the issuance in 1921 of an injunction restraining township from polluting waters of Hackensack River and tributaries. A modern sewage treatment plant, including settling tanks and glass-covered sludge drying beds, has recently been completed.—*G. C. Houser.*

Reservoir Covering Pays Dividends. C. W. Klassen and H. F. Ferguson. Illinois Health News, 14: 4, 106, April, 1928. Edwardsville Water Co. recently invested $1500 in covering an open storage reservoir at the suggestion of State Department of Public Health, and thereby made net annual saving of $61.50. Supply is pumped from wells into concrete storage reservoir with capacity of 250,000 gallons. Before it was covered a luxuriant growth of algae necessitated cleaning twice monthly.—*G. C. Houser.*

Florida Regulation Governing Impounding of Waters. Florida Health Notes, 20: 4, 59, April, 1928. State Board of Health has passed a rule, effective May 1, 1928, providing that no person, firm, or municipality shall impound any body of water within State of Florida, whose surface area shall exceed one acre, without first securing written permission from State Board of Health. Violation of this rule is punishable by imprisonment not exceeding 30 days or a fine not exceeding $50.00.—*G. C. Houser.*

The Great Lakes Drainage Basin Sanitation Agreement. Monthly Bulletin, Indiana State Board of Health, 31: 3, 33, March, 1928. Health commissioners of Minnesota, Michigan, Wisconsin, Illinois, Ohio, Indiana, Pennsylvania, and New York have recently agreed to cooperate with each other and with United States Public Health Service in carrying out a policy for improvement of quality of waters of interstate lakes and their tributaries in these states, by prevention or correction of undue pollution thereof.—*G. C. Houser*.

Public Health Council of New York State Refuses to Modify Order Eliminating Cross Connections. Monthly Bulletin, Ind. State Board of Health, 31: 3, 33, March, 1928. In November, 1925, New York State Public Health Council adopted an order requiring elimination by July 1, 1928, of all cross connections between potable and non potable water supplies. Recently, after careful study of the question, the council has declared that "the complete severance of potable and polluted waters is demanded for the protection of the public health and that this can be accomplished without increasing fire hazard to life or property."—*G. C. Houser*.

Paper Wastes: Investigation of the Recirculation and Treatment of Waste Waters from the Process of Paper Making. I. R. Riker. Public Health News, Department of Health of State of New Jersey, 12: 10–11, 290, September–October, 1927. The mill investigated and reported on, has 4 paper making machines. All waste white water was being reused. Two recirculating systems were operated. One used chemical precipitation of water and this water was used for felt showers with make-up waste rates of 3 to 1. Other system returned waste white water direct from pits to breakers or beaters. Chemical precipitation plant handles all water over and above that used by breakers or beaters. "Boothall," a balanced coagulant is used. Reclaimed stock from precipitation plant makes up 20 per cent of the material used by No. 1 machine; that is, 15 tons of finished material is procured from 12 tons of old newspaper stock (raw material). After the investigation was made it was reported that all waste white water was being used and that for long periods it was unnecessary to pollute the creek with this waste.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.)*.

Annual Report. Department of Health, Government of Palestine, 1926. 92 pages. Typhoid fever epidemics occurred in Emek Jezriel, Tel Aviv and Jerusalem, with 206, 223, and 280 cases, respectively. The total incidence for the country was 1,402, compared to 705 in 1925. There was no further evidence to incriminate water as the definite cause, nor could the outbreaks be attributed to milk or other foods, though in some towns the sale of vegetables fertilized with sewage constituted a constant possible means of spreading infection. Water supplies: due to deficient supply of pure water in Jerusalem, contaminated surface supplies were resorted to after chlorination. The supply of water varied from 50,000 to 230,000 gallons per day. A large number of villages improved their water supplies.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.)*.

Rural Water Supplies—The Advantages of Decentralization. D. T. Worger. The Surveyor, 72: 1870, 513, November, 1927. The Bruston patent auto-pneumatic water supply system, which briefly consists of an automatically controlled gas engine or electric motor and a pressure tank, is recommended in decentralized units for use in rural districts where the expense of a centralized water supply system is prohibitive. The advantages of such a system are illustrated in the case of a rural district which contained 25 small parishes varying in population from less than 100 to 1,000 and having a total population of 8,439. This district may be divided into 4 groups of villages, 2 groups to be served by one pumping station and the other two groups to be served by one pumping station each. Comparison of costs for such a decentralization system for the above district with a centralized system was favorable toward the decentralized system.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Absts.).*

Water Purity and Fish Life. W. Rushton. Surveyor, 72: 1872, 574. December 9, 1927. The care to preserve river water for drinking purposes and the lack of attention to preserving the natural fauna and flora when the waters are required for other purposes are the main subjects of the paper. Pure water will not support fish life, because of the absence of a suitable food supply. Also, if certain ingredients are absent, diseases, including goiter, will appear among fish. If rivers must receive effluents from various works, they should not destroy the natural fish life or permit foreign growths killing natural ones. Evidence exists that waters from producer gas plants harm small streams owing to presence of sulphur compounds and carbon monoxide in solution. Effluents from coal washing plants and coke ovens are known to harm river waters for fish life.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.).*

Report on Electrolux Water Softener. Anonymous. Journal of State Medicine of Royal Institute of Public Health, 36: 1, 49, January, 1928. The electrolux softener used in the experiment consisted of a tinned-copper cylinder 1 by 8 inches high and 5 inches in diameter, containing a special kind of earth treated in a particular manner but composed mainly of alumina and silica. Periodically the softening material must be regenerated with dissolved common salt. The conclusions arrived at from the experiments are as follows: (1) By analysis it is found that all the hardness is removed from the water; (2) that no deleterious ingredient could be detected in the softened water; (3) that this method of water softening is very simple, economical and efficacious.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Absts.).*

Water Supply in Bradford (England). Lewis Mitchell. Surveyor, 73: 1876, 3, January 6, 1928. This report illustrates several divergent points of view on English and American Water Works practice. The city population of 288,700 consumes 58.1 gallons per capita, 35.3 gallons per capita of which are for domestic and 22.8 gallons for industrial purposes; the corresponding consumption of outlying districts with a population of 100,000 is 31.4 and 18.9 gallons per capita, respectively. Yet the statement is made that "although it is only one third of the quantity consumed in 'dry' American cities, it is

greatly in excess of what is reasonably required." Metering of domestic services is not advocated for sanitary reasons. Chlorination is not considered "expedient or desirable which may be considered purely as a last line of defence." Filtration is provided as a further safeguard for supplies from practically uncontaminated sources. The difficulty of finding pure sources requiring no chemical treatment is in many cases becoming acute but Bradford has provided against this contingency. The water is at times plumbo solvent, containing as high as 0.113 grains per gallon of lead. The acidity is neutralized by a "harmless reagent" to correct this solvent action.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.).*

Contrôle Technique D'Une Installation Municipale De Sterilisation D'Eau Par L'Ozone. (Control of a Municipal Plant for Purification of Water by Ozone.) J. Salmon and P. Quarre. Bulletin of Hygiene, 2: 12, 978, December, 1927. A description of the water disinfecting plant of the city of Boulogne consisting of an ozonizer and the circulating system for ozonized air and the sterilizer or disinfecting unit. The ozonizer consists of a series of glass cylinders, a coaxial aluminum rod which serves as one electrode and the aluminum enclosing case serves as the other electrode. A single phase, 50 cycle, alternating current transformed to 8,000 to 10,000 volts is applied to the electrodes. Air dried by calcium chloride is forced through the cylinders in which the silent electrical discharge occurs generating the ozone. This ozonized air is forced through a sterilizer, consisting of a vertical tower of reinforced concrete divided at intervals by horizontal partitions of perforated celluloid to insure intimate contact between the water and the ozonized air, which both enter at the base of the tower. The effluent from the sterilizer is tested periodically with starch iodide for free ozone and in the manner used for determining the residual chlorine in water. Bacteriological data are given indicating that the number of B. coli per liter was reduced from 1,000 to 0 and the gelatin count was reduced from 714 to 6 per cubic centimeter—*A. W. Blohm (Courtesy U. S. Public Health Eng. Absts.).*

Interesting Features of a Rural Outbreak of Cholera Due to Infected Drinking Water. Hilario Lara. American Journal of Hygiene, 7: 5, 606, September, 1927. This article gives an account of an outbreak of cholera occurring in a rural community in the Philipines, which was found to have resulted from the drinking water from an infected spring. Among the data presented are: Clinical and bacteriological findings; record of previous attacks or inoculation, and results of the epidemiological investigation.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Absts.).*

Sanitary Engineering Progress in the Middle West. Wynkoop Kiersted. Proceedings of Tenth Texas Water Works Short School, January, 1928. The author reviews the changes in engineering practice which have occurred in the Middle West. He advocates the use of gumbo for a waterproofing material describing the impounding reservoir constructed at Council Bluffs in 1882. Gumbo can also be used to fill the joints between concrete slabs, as an expansion joint in joining some types of concrete walls, and for packing the annular

space around C. I. pipe where it passes through a concrete wall. Sedimentation and sterilization show the most marked improvements in water purification. The Kansas City water supply is given as an example that safe, potable water can be produced by sedimentation and chlorination alone. Filtration is entirely dependent upon the efficiency of settling basins. Changes in methods of sedimentation are described.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.).*

The Trend of Typhoid Fever Mortality in the United States. PERSIS PUTNAM. American Journal of Hygiene, 7: 6, 762, November, 1927. This article gives a rather complete analysis of the decline of the typhoid fever death rate in recent years in the United States. In order to analyze the trend of the typhoid fever death rate for the period 1900–1925, a group of ten states was used where data for the earlier years was available. The death rate in the Registration States of 1910 and 1920 are then compared and the differences between white and colored rates discussed. In order to visualize the trend of typhoid fever mortality over a longer period of years than is possible for any considerable portion of the United States, the record of certain large American cities are presented. There are a number of tables listing data for various cities, states and groups for certain periods. There are also a number of figures showing curves and graphs in connection with typhoid fever mortality for the United States as a whole and various portions.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.).*

Chlorination of Water Supplies in Assam. R. T. SEN. Proceedings of Assam Branch British Medical Association Annual Meeting, Silchar, March 1 and 2, 1926, 43. Bulletin of Hygiene, 2: 8, 649, August, 1927. Chlorination of the Sylhet water was started in July, 1922. Results were unsatisfactory at first and this was ascribed to improper dosage. With experience the defects were remedied, the total count was low and except for one occasion in February, 1925, lactose fermenters were absent from 20 cc. In Silchar, chlorination was begun in May, 1924, and the results obtained were good from the start. Tables are given showing the bacterial improvement in the water supplied as compared with pre-chlorination figures.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.).*

A Note on the Purification of Water from Rivers Polluted by Sisal Effluent. F. C. KELLY. Kenya Medical Journal, 1926, 3: 212–15, Bulletin of Hygiene, 2: 8, 651, August, 1927. Samples of water were taken from and near a river flowing through three sisal estates in Kenya. The introduction of sisal waste at the factories results in marked deterioration of the quality of the river water, as judged by the oxygen absorbed and albuminoid nitrogen figures. The oxygen absorbed seems a very convenient test for the extent of pollution by sisal effluent as the latter contains some as yet unidentified compound which exerts marked reducing properties. The water from two wells in the zone of pollution was examined. The water from the river receives natural filtration on its way to the well and the conclusion is drawn that sisal pollution is removed by filtration.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abst.).*

Quality of the Surface Waters of New Jersey. W. D. Collins and C. S. Howard. Water Suppyl Paper 596-E, United States Geological Survey, Department of the Interior, 119 pages. The surface waters of New Jersey are one of the most valuable natural resources of the State. They are used for public water supplies of nearly all the larger cities, and they furnish the great quantities of water required for some of the leading industries. Where unpolluted, these waters are generally clear and contain only moderate quantities of dissolved mineral constituents. The waters in the southern part of the State are softer but more highly colored than the waters in the northern part.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Intestinal Affections and Drinking Water Supply on Curacao. P. H. Van Der Hogg. Nederl. Tijdschr. V. Geneesk., 1926, December 18, 2788–96. Bulletin of Hygiene, 2: 8, 653, August, 1927. The difficulty of providing the island with suitable water supplies is the quality of the ground water, which is often brackish. The soil of Curacao has during long periods been covered by the sea and locally still contains large quantities of salt, which remained in the soil by evaporation of the water after the island rose above the sea level. This salt is washed out by the rainwater from the more porous soil, but is still present in the less permeable ones. With regard to the chemical composition of the water and the bacteriological reliability, the author discusses the possibilities of establishing a satisfactory water supply. This part of the article is of merely local interest.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Report on an Outbreak of Illness at Poplar Suspected to be Due to Local Pollution of the Water Supply. G. C. Hancock. Bulletin of Hygiene, 2: 12, 982, December, 1927. An outbreak of illness characterized by very severe diarrhoea of sudden onset, accompanied by fever, occurred in Poplar, England. The cases occurred in a relatively small area. Records of the analyses of samples of tap water examined by the Metropolitan Water Board of London indicated that locally the tap water was of an inferior quality. Further investigation disclosed the presence of a cross connection of a private water supply of a gas plant and the public mains. No check valves were used on this cross connection.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Problem of Bilharziasis in Egypt. Ali Bey Ibrahim. The Journal of State Medicine, 35: 12, 702, December, 1927. This disease, one of the most prevalent in Egypt at the present time, is essentially a water-borne disease. The eggs of the worms are hatched in fresh water and carried by snails to infect human beings through perforations of the skin or mucous membranes. In order to kill these snails and thus to prevent the spread of the disease, dryness is necessary. It is therefore recommended in the article that Egypt be divided into four districts and that irrigation be completely stopped in one of these divisions each year, thus resulting in complete dryness of that district except for the provision of drinking water. In addition, the Department of Health will concentrate all efforts to the treatment of infected cases in that area and will use copper sulphate to kill the snails in local areas which do not get thoroughly dry.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Rivers Pollution Prevention Work of the West Riding Board. Anonymous Surveyor, **73**: 1883, 260, February 24, 1928. The streams, with tributaries, under survey of the Board had a total length of over 2000 miles, including some clean rivers, and others in various states of pollution. There are now 427 sewage works in the Board's area, compared with 167 in 1896. Many works, however, have been abolished, with the process of concentration still going on.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Sterilization of Small Quantities of Water. D. T. M. Large. Journal of the Royal Army Medical Corps, 1927, **49**: 77–8. Bulletin of Hygiene, **2**: 12, 979, December, 1927. A solution is made by adding stabilized bleaching powder to a 4 ounce medicine bottle; about 1 inch depth in the bottom of the bottle suffices. The mixture is well shaken, and after settling out, the supernatant liquor forms the sterilizing solution. A glass of water is sterilized by stirring with a match previously dipped to the hilt in the sterilizing solution. For a soldier's water bottle a wire of the thickness of a match dipped in the solution for a few inches is enough. Ten drops is recommended for a wash basin as fitted in Indian trains. Diluted seven times with water the sterilizing solution forms a good wound antiseptic.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Swimming Pool—Its Care and Aims. Francis E. Fronczak. Journal of the American Association for Promoting Hygiene and Public Baths, **9**: 38, 1927. The article discusses the subjects of design, supervision and maintenance of indoor swimming pools, touching upon some of the more important factors of each.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Typhoid Fever in Cleveland, 1873–1926. Roger G. Perkins. Journal of Preventive Medicine, **1**: 7, 449, September, 1927. This article is a very good historical review and discussion of the typhoid fever situation in Cleveland, Ohio, since 1873. About 75 per cent of the article is devoted to the relation of the water supply and the method of sewage disposal to this disease. Other etiological factors discussed include milk and other foods, contacts and flies.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Report of Division of Sanitary Engineering. Fifth Annual Report of the Provincial Bureau of Health, Province of Quebec, Canada, 1926–1927, 151. Information is given on new waterworks and sewerage systems constructed in municipalities of the Province during the year, also of additions and improvements to other plants. There are 47 municipalities and 3 institutions with filtered water supplies, the population of the municipalities being about 1,000,000. Thirty-three other towns with a population of about 150,000 are supplied with chlorinated water only. These installations are supervised by the Sanitary Engineering Division through daily analyses and inspections by a special division engineer.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Water Purification. P. H. Henderson. Journal of the Royal Sanitary Institute, **48**: 9, 481, March, 1928. This article contains a brief summary of the methods used by the British army prior to and during the World War in the provision of drinking water. Army units were provided with one or more water carts, the main tank of each cart containing 110 gallons of water. The water was pumped from the source by semi-rotary pumps through compressed sponge, contained in cylinders, into the main tank and thence through porcelain filter candles into a smaller tank from which the water bottles were filled. It was found that the sponges did not act as efficient clarifiers, that it was impossible to ascertain whether the filter candles were free from flaws or were allowing the passage of bacteria, and that it was difficult to secure a bacterium-proof junction between the candles and the caps of the cylinder to which they were attached. During the war, Sir William Horrocks introduced the use of aluminum sulphate as a precipitant and chlorine as a sterilizing agent.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

The Rôle of Ammonia in the Purification of Water. C. H. H. Harold. Journal of the Royal Sanitary Institute, **48**: 9, 484, March, 1928. During the 1925 manoeuvres of the British Army, Major Harold introduced a new method of purifying water. This method consisted in preliminary treatment with ammonia followed by sterilization with chlorine. In this way the absorption of chlorine is restrained and its germicidal powers are enhanced. The sterilizing agent is not unduly deviated by organic matter and a safe water is produced, practically free from unpleasant tastes. The chlorine solution was given initial contact with the ammonia prior to dosing into water and the highest concentration which did not show evidence of available chlorine was fixed upon as the optimum. Normally each water cart having a capacity of 110 gallons is dosed with 1.25 grains of ammonium bicarbonate and about 3 grams by weight of dry chlorine gas.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Removing Iron from Drinking and Industrial Water. A. Battige. Apparatebau 39, 306–8 (1927). From Chemical Abstracts, **22**: 6, 1000, March 20, 1928. Aeration in coke-filled towers and filtering through sand is described.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abst.*).

Small Iron Removal Plant for Red Bank Water Works. Wellington Donaldson. Eng. News-Rec., **100**: 112–4, 1928. An illustrated description of the 1.5-million gallon per day purification plant recently put in commission at Red Bank, N. J., which consists of a cascade aërator, 3 horizontal pressure filters, and chlorinating equipment. The supply is derived from drilled wells and contains excessive amounts of CO_2 (18 p.p.m.) and Fe (2.5 p.p.m.), the latter causing difficulties due to staining. Preliminary experiments showed that whereas upward flow contact towers filled with gravel reduced the iron content only to 1.0 to 1.1 p.p.m., sand filters effected practically complete removal (0.05 to 0.07 p.p.m.). The filters are 8 by 25 feet, and are equipped with perforated pipe underdrains. Growths of filamentous algae in distribution reservoir proved troublesome at first but these have been

completely eliminated by chlorination at the rate of 0.48 p.p.m. The cost of the plant was $52,881.—*R. E. Thompson (Courtesy Chem. Abst.).*

High Head Hydro-Electric Project on Bucks Creek. Eng. News-Rec., **100**: 140–3, January 26, 1928. Brief outline and résumé of statistical information of major features of Bucks Creek project of Feather River Power Company, on Feather River. Operating head on turbines will be 2561 feet (static). —*R. E. Thompson.*

Simple Method Used to Lower Cast-Iron Water Main. Eng. News-Rec., **100**: 161, January 26, 1928. Brief description of method employed in Springfield, Mass., for lowering mains following surface grade alterations without shutting off pressure. Mains lowered were cast iron pipes from 4 to 30 inches in diameter with both lead and composition joints. Little difficulty has been experienced with leakage.—*R. E. Thompson.*

Cross-Section Rod and Protractor for Tunnel Work. DANIEL MCFARLAND. Eng. News-Rec., **100**: 164, January 26, 1928. Brief illustrated description of instruments used for cross-sectioning tunnels of Bucks Creek project.—*R. E. Thompson.*

Power Shovels for Handling Rock Save Time on Rock Fill Dam. Eng. News-Rec., **100**: 163, January 26, 1928. Brief illustrated outline of adaptation of power shovels to handling heavy rock fragments used in facing upstream side of rock fill dam on Bucks Creek project of Feather River Power Company.—*R. E. Thompson.*

Building a Penstock to Develop a Static Head of 2561 feet. OSWALD SPEIR, Jr. Eng. News-Rec., **100**: 191–5, February 2, 1928. Detailed illustrated description of penstocks for Bucks Creek development of Feather River Power Company. Head involved constitutes record in United States.—*R. E. Thompson.*

Penstock Wyes Withstand Pressure of 2230 Pounds per Square Inch. Eng. News-Rec., **100**: 246, February 9, 1928. Brief description of wyes installed in Bucks Creek plant of Feather River Power Company.—*R. E. Thompson.*

Traveling Concrete Plants Line Cascade Tunnel. Eng. News-Rec., **100**: 224–7, February 9, 1928. Illustrated description of methods being employed in placing 200,000 cubic yards of concrete lining in Cascade tunnel. Inside dimensions of tunnel are 16 by 22 feet, and volume of lining per linear foot is 4¾ cubic yards.—*R. E. Thompson.*

Picnic Grounds Adjoin Water Works Reservoir. Eng. News-Rec., **100**: 235, February 9, 1928. New Brunswick, N. J., has established picnic grounds in grove immediately adjoining new 1000 m.g. water supply reservoir completed in March, 1927. No attempt is made to prevent use of reservoir for bathing and boating. The water spills over concrete dam and is collected

in second reservoir, from which it is pumped to purification plant consisting of filters and chlorinating equipment.—*R. E. Thompson.*

Ferric Salts as Coagulants for Activated Sludge Prior to Filtration. F. W. Mohlman and J. R. Palmer. Eng. News-Rec., **100**: 147–50, 1928. Experiments at the Calumet sewage works in 1923 indicated that alum was the most satisfactory coagulant. Later experiments carried out as a result of interference by trade wastes have shown that ferric salts, particularly $FeCl_3$, are decidedly superior to the corresponding Al salts, the floc particles being much larger. With equivalent weights of Fe and Al, the chlorides filtered most rapidly, the nitrates being second, and the sulfates the slowest. The best results with any of Al salts were but slightly better than the poorest ferric salt. Experience at a number of activated sludge plants have confirmed the conclusion that ferric salts are very efficient coagulants. As the cost of $FeCl_3$ is very high, 6 cents per pound, compared with 1.5 cents per pound for alum, the production of ferric salts was investigated. All processes studied were finally abandoned in favor of oxidation of $FeSO_4$ with Cl_2, which produces a mixture containing 71 per cent $Fe_2(SO_4)_3$ and 29 per cent $FeCl_3$. Apparatus devised for this process is described. It is possible to effect 98 to 99 per cent oxidation without appreciable loss of Cl_2. Results with this mixture were much superior to those obtained with alum. Chlorine alone has little coagulating effect.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Making Pneumatic Arch Closures in Tunnel Work. Aaron Evans. Eng. News-Rec., **100**: 164, January 26, 1928. Brief illustrated outline of method used during concreting of Chelan tunnel, Washington.—*R. E. Thompson.*

Concrete Gun Lining Work in Duboce Tunnel. Eng. News-Rec., **100**: 201–4, February 2, 1928. Illustrated description of placing of lining in Duboce tunnel in San Francisco, a municipal traffic improvement, 4,232 feet long.—*R. E. Thompson.*

The Bacteriological Examination of Water and Interpretation of Results. G. B. Reed and C. M. Anderson. Pub. Health J. (Can. Pub. Health Assocn.) **19**: 43–4, 1928. A brief description of bacteriological tests and their significance.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Novel Crest Design for Thin Overpour Dams. J. C. Stevens. Eng. News-Rec., **100**: 227, February 9, 1928. Brief illustrated description of crest design for thin arch dams which permits use of this type of structure where overflow is of large volume. Stability of pure arch dam does not depend upon load on stream bed but upon stability of canyon walls to which arch thrust is transmitted. Wearing away of rock in stream bed is therefore of secondary consideration as long as it does not wear enough at immediate toe of dam to affect water seal or to weaken ability of foundation to support vertical weight of dam. By providing suitable lip on crest of dam and making provision for completely aerating the space between the nappe and the dam the nappe may be projected so as to strike stream bed a distance below toe

equivalent to nearly two-thirds the height of dam. In absence of piers on dam crest complete aeration may be secured by use of "slitter beams" projecting through nappe.—*R. E. Thompson.*

Action of Pure Water on Cement Mortar Briquets. Eng. News-Rec., **100:** 236–7, February 9, 1928. Results of experiments covering period of one hundred weeks on effect of water on cement mortar briefly given. Distilled water has decided disintegrating effect on portland cement mortar, whereas calcareous river water has no effect whatever. Disintegration is believed to be due to dissolution of free lime. On setting of sliceous or silico-aluminous cements, hydrated monocalcium silicate is formed and hydrate of lime liberated, latter being readily soluble in pure water. When in contact with calcareous waters, however, the lime precipitates calcium carbonate, which closes pores of mortar, thus protecting it. High alumina cement (ciment fondu) was scarcely affected by distilled water. During hydration of alumina cement hydrated monocalcium silicate and dicalcium aluminate are formed and alumina instead of lime is liberated. This explains its resistance to effect of water.—*R. E. Thompson.*

Shore Assembly for Laying Subaqueous Sewer Pipe. Paul J. Jones. Eng. News-Rec., **100:** 414, March 8, 1928. In construction of sewers in North Wildwood, N. J., ingenious method of laying pipe across Hereford Inlet was devised. Track was laid on shore in line with position pipe was to occupy, and pipe was then laid on ties between the rails and suspended from cars built of medium heavy timbers rigidly bolted. Trench was then dredged in bed of inlet and track placed therein and pipe was pushed into water on cars and dropped into position.—*R. E. Thompson.*

Pipe Line Laid Under Water by Ingenious Method. Eng. News-Rec., **100:** 415, March 8, 1928. To provide water supply for condensers of Ohio Public Service Company, at Lorain, Ohio, a 48-inch reinforced-concrete pipe has been laid to inlet, which is 700 feet out in lake. Water was formerly supplied through 30-foot channel between piers running from screening house to plant, but this was unsatisfactory owing to ice difficulties. Power shovel with back-digger bucket was used for all operations in laying of pipe. Machine dug trench in shifting sand, set pipe and backfill, and drove necessary piling from position on pier. Pipe was laid about 18 feet from pier. Two men, with shoulder-high wading boots, cemented pipe on inside at bottom and on outside at top. Strips of cement bags were laid over fresh cement to protect it from wash and from disturbance during backfilling, which was carried out immediately. Work was completed in less than 3 weeks.—*R. E. Thompson.*

Tabulation of Test Data on Unit Strength of Welded Joints. Eng. News-Rec., **100:** 237, February 9, 1928. Compilation of tests of strength of welded joints.—*R. E. Thompson.*

Practical Water Filter Plant Operation. S. T. Powell. Cont. Rec. and Eng. Rev., **41:** 1082–4, 1927. A general discussion, including coagulation

control, air binding of filters, etc. It is pointed out that no single operation requires more care than the opening and closing of valves. Rapid opening of filter effluent valve results in violent shock to filter, causing holes and channels in sand bed. This not only impairs filter efficiency, but may permanently injure bed by drawing floc or even sand into under-drainage system. —*R. E. Thompson* (*Courtesy Chem. Abst.*).

Two New Type Electrically Driven Pumps for Cleansing Bay. GEORGE E. FOX. Cont. Rec. and Eng. Rev., 41: 1138-9, November 9, 1927. Brief illustrated description of two 75 horsepower, 30 m.g.d., centrifugal irrigation pumps installed at Toronto, Ont., to pump water from Toronto Bay approximately ½ mile against total head of 9 feet to create flow through Ashbridge's Bay. The latter bay has only one small outlet to Lake Ontario and there was not sufficient circulation to prevent nuisance from pollution entering bay through various drains and channels discharging therein.—*R. E. Thompson.*

Some Essentials for Thin Dams. C. E. GRUNSKY. Eng. News-Rec., 100: 416, March 8, 1928. Discussion of requirements in design of concrete dams. Importance of imperviousness is stressed. Analysis of white efflorescence scraped from face of one concrete dam showed it to contain 97 per cent calcium carbonate.—*R. E. Thompson.*

Temperature and Humidity Control in Rooms for Concrete Study. Eng. News-Rec., 100: 395-6, March 8, 1928. Illustrated description of portion of University of California laboratory which has been equipped with automatic devices for controlling temperature and humidity for concrete testing. Desired atmospheric conditions can be maintained with variations of less than 1 per cent.—*R. E. Thompson.*

Early-Strength Concrete Made with Ordinary Cement. WALTER CAHILL. Eng. News-Rec., 100: 412, 1928. Concrete made with a mix of approximately 1:1½:3 and water-cement ratio of a little less than 6 gallons per sack of cement had an average compressive strength of 2500 pounds per square inch at three days, 3700 pounds at seven days and more than 5200 pounds at twenty-eight days.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Germany Prohibits Impure Water by Law. Eng. News-Rec., 100: 362, March 1, 1928. New pure food law, in effect October 1, 1927, includes drinking water among articles which may not be adulterated or polluted. Most supplies for German cities are derived from wells or springs and only when such source is not easily available are surface waters used as supply. Surface waters are purified by slow filtration through sand, with use of clarifying agent. In recent years there has been more general treatment with chlorine. Berlin supply is obtained chiefly from deep wells and is free of pollution. Only treatment required is for reducing mineral content. Hamburg supply, derived from River Elbe, is purified by sand filtration and pre- and post-chlorination.—*R. E. Thompson.*

Forecasting Mississippi Flood Stages. Isaac M. Cline. Eng. News-Rec., 100: 277–9, February 16, 1928. Description of methods employed by Weather Bureau, New Orleans.—*R. E. Thompson.*

Mississippi River Flood Control. W. W. DeBerard. Eng. News-Rec., 100: 63–6, January 12, 1928. Summary of events, conditions and plans.—*R. E. Thompson.*

Earth Moving Mechanized. Has. H. Paul. Eng. News-Rec., 100: 67–9, January 12, 1928. Inventory of power tools available for mass excavation, transportation, and placing of earth.—*R. E. Thompson.*

Ortho-Tolidin Test for Water Chlorination. T. J. Lafrenière and A. E. Berry. Pub. Health J. (Can. Pub. Health Assocn.), 19: 1, 42–3, 1928. An outline of the *o*-tolidin test for free Cl_2 and its application to the control of chlorination. The standards of the Ontario Department of Health require a residual Cl_2 content of 0.2 to 0.3 p.p.m. (after fifteen minutes) in water supplies, and 0.2 to 0.5 in swimming pools.—*R. E. Thompson (Courtesy Chem. Abst.).*

Ice and Leakage Troubles on Water Supply Pipe Lines. Chas. Brossmann. Eng. News-Rec., 100: 150, January 26, 1928. Water supply of Michigan City, Ind., is drawn from Lake Michigan through 24-inch intake extending 2,750 feet into lake and 42-inch cast iron intake pipe extending 3,000 feet into lake. Supply from latter failed in January, 1927, and investigation showed inlet to be blocked with ice. The 4-inch openings in the protecting timber screen, 30 feet below surface, were also closed solid, and the ice eventually built up to surface. Water is conveyed from pumping station across harbor to city by two pipe lines, 24 and 30 inches in diameter. Shortly after ice troubles the consumption increased from normal of 5 m.g.d. to 7 or more. Investigation by diver disclosed break in 30-inch cast iron line. When broken pipe section was raised it was found that it had cracked around flange, probably when laid fourteen years before. Constant erosion had widened crack and even heads of 1½-inch flange bolts had been worn away. Later another leak was found, a crack ⅛ to ¼ inch wide running entire length of one section. It is proposed to construct concrete tunnel under harbor to carry the water pipes.—*R. E. Thompson.*

Bridge River Power Project, B. C. Eng. News-Rec., 100: 81, January 12, 1928. Construction is well under way on 2½-mile tunnel, 13 feet in diameter, which is initial step in British Columbia Electric Railway Company project. —*R. E. Thompson.*

Construction of Multiple-Arch Dam in Arizona. Eng. News-Rec., 100: 180–3, February 2, 1928. Illustrated description of construction of Lake Pleasant dam, completed in September, 1927, on the Agua Fria River by Maricopa County Municipal Water Conservation District No. 1 for irrigation and power purposes. Dam is 1,830 feet long on high water line and 2,146 feet

to ends of cutoff walls, not including 750-foot spillway. Greatest height above foundation is 252 feet.—*R. E. Thompson.*

The Mercier Reservoir on the Gatineau River. Cont. Rec. and Eng. Rev., **41**: 1182–5, November 23, 1927. Illustrated outline of recently completed power project of Canadian International Paper Co. on Gatineau River, consisting of enlarging Lake Baskatong to area of 64,000 acres by construction of 10 dams; 3 of concrete, 4 earth fill, and 3 rock fill. Reservoir thus formed is third largest artificial reservoir in world, impounding 95,000 million cubic feet.—*R. E. Thompson.*

New York Water Supply Extensions. Eng. News-Rec., **100**: 85, January 12, 1928. Approval has been given by Board of Estimate of plans for new pressure tunnel, 17 feet in diameter at upper end and some 20 miles long, to supplement one already in use for delivering water from Catskill aqueduct system. Studies for tunnel are under way. Recommendations for an additional supply of 600 m.g.d. from five New York tributaries of Delaware River and 70 to 100 m.g.d. from Rondout Creek, a tributary of the Hudson, together with diversion of water from some of higher levels of Croton system into Catskill system, have been submitted to the Board. Proposal to develop 150 m.g.d. from wells on Long Island for emergency use was also before Board of Estimate at close of year.—*R. E. Thompson.*

Chlorophenol Tastes Pervade Chicago Water Supply. Eng. News-Rec., **100**: 115–6, January 19, 1928. Severe period of taste-producing pollution of water of southern end of Lake Michigan occurred December 23–30, 1927, when water supplies of Chicago, Ill., Gary, East Chicago, Whiting, and Hammond, Ind., were rendered undrinkable. Phenol content was about 60 parts per billion. Investigation indicated that industrial wastes were discharged from Indiana Harbor ship canal, apparently in intermittent batches, and driven in direction of intakes by heavy gale. Drift of the pollution was 17½ miles in fourteen hours, or 1¼ miles per hour. Industrial waste pollution was accompanied by heavy bacterial contamination and chlorine absorption increased to such an extent that dosage required at Chicago was as high as 13.6 pounds per million gallons. Residual chlorine considered necessary to insure safe water at Chicago is 2 to 2.5 pounds per million gallons.—*R. E. Thompson.*

Use and Waste of Irrigation Water. Eng. News-Rec., **100**: 114, January 19, 1928. Brief compilation of data on irrigation consumption and loss in canal seepage and waste on federal reclamation projects. Data indicate that less than one-half of water taken from supply stream is used on land, one-sixth is lost at canal wastages and spillways, and about 40 per cent in seepage through canal bottoms.—*R. E. Thompson.*

Failure of Non-State-Inspected Dam Under Construction. H. T. Critchlow. Eng. News-Rec., **100**: 116, January 19, 1928. Recent failure of small dam under construction in New Jersey illustrates need of state supervision

of dams, even of those impounding water from small collecting areas. Dams impounding water from area of less than 1 square mile are now classed with those less than 5 feet high in being exempted from state supervision. Dam in question failed during severe storm on November 17, 1927. It was located on small branch of Peapack Brook and was to have been of earth-fill and concrete core-wall type, with maximum height above stream bed of 32 feet and total length of 360 feet. Evidence points to failure due to slumping of center portion of downstream fill.—*R. E. Thompson.*

Building of Guernsey Irrigation and Power Dam. F. F. SMITH. Eng. News-Rec., **100**: 264–8, February 16, 1928. Illustrated description of construction of Guernsey dam on North Platte River in Wyoming forming impounding reservoir of 72,000 acre-feet capacity. Dam is composite structure of loose rock and sluiced gravel and clay, with puddle core extending from 30 feet below river bed to crest. Dam height above stream bed is 105 feet, crest length 560 feet, and base thickness 1000 feet. The 26-foot crest forms a driveway. The 1:3 upstream slope is protected by 3 feet of riprap.—*R. E. Thompson.*

Diablo Dam, Skagit Project. Eng. News-Rec., **100**: 81, January 12, 1928. A $2,263,000 contract was awarded in September for construction of Diablo Dam on Skagit River, a unit in hydro-electric project of Seattle, Wash. Dam will be constant angle arch, creating 90,000-acre-foot reservoir. Length of arch will be 775 feet and total length 1,100 feet. Contract calls for completion in September, 1929.—*R. E. Thompson.*

Building a Rolled-Fill Dam of Pre-wetted Earth. RALPH LOWRY. Eng. News-Rec., **100**: 388–91, March 8, 1928. Illustrated description of construction of McKay gravel-fill dam recently completed by U. S. Bureau of Reclamation on McKay Creek, Oregon, being part of Umatilla federal irrigation project. Construction was started in July, 1923, and completed in December, 1926. Embankment, containing 2,287,000 cubic yards, has top length of 2,700 feet, maximum height above creek channel of 165 feet, a 1 on 2 down stream slope and unusual upstream slope of 1 on 1.75. Advantage was taken of unusually stable embankment material available to give somewhat steep slope, resulting in saving of $500,000 as compared with 1 on 3 upstream slope commonly used for earth-fill dams. Upstream face is covered with continuous slab of reinforced concrete paving. Dam creates reservoir 4 miles long by 1 mile wide, with storage capacity of 73,000 acre-feet. Estimated cost was $2,500,000 and acutal cost, $2,115,197.12.—*R. E. Thompson.*

Mokelumne Water Supplies. Eng. News-Rec., **100**: 81, January 12, 1928. Progress outlined. Outlet tunnel for Pardee reservoir, 2.2 miles long, was started in July and on December 15 headings had been advanced 1900 feet. Both this tunnel and Claremont tunnel, 3.4 miles long, at lower end of line, are scheduled for completion in 1929. Dam was commenced in July, 1927. Early in December, 82 per cent of 65-inch aqueduct was in place. Completion is expected in 1928.—*R. E. Thompson.*

Hetch Hetchy Water Project. Eng. News-Rec., 100: 81, January 12, 1928. Brief data on progress in 1927 on Hetch Hetchy aqueduct, which will convey water from headwaters of Tuolumne River 168 miles to San Francisco. The 16 miles of 13 by 14-foot tunnel in foothill division is approaching completion. Uncompleted gap includes 45 miles of steel pipe to be built across San Joaquin Valley and 30½ miles of tunnel through Coast Range Mountains. This work will occupy about four years.—*R. E. Thompson.*

ABSTRACTS, SUB-COMMITTEE NO. 9

Joint Research Committee on Boiler Feedwater Studies

The Significance of the Corrosion Question in Practical Boiler Operation. A. Splittgerber. Korrosion Metallschutz 3: 149–53, 1927. Chem. Abstracts, May 20, 1928, 22: 1817. A discussion of the influence of the chemical nature of feed water, of localized overheating, of O_2 content of water, of boiler pressure, of oils in the boiler water, and of temperature on the corrosion of preheaters, boilers, superheaters, turbines and condensers in boiler systems. —*J. K. Roberts.*

Corrosion of Iron and Steel, with Special Reference to Marine Boilers. W. B. Lewis and G. S. Irving. Shipbldrs. (Newcastle-on-Tyne), 35: 213, May, 1928, pp. 343–345. Differential-aëration corrosion; factors which influence corrosion; prevention of corrosion. Paper presented before Institution of Marine Engineers.

Boiler Explosion at a Fifeshire Colliery. Colliery Guardian (Lond.), 136: 3510, April 5, 1928, p. 1377, 1 fig. Review of report of preliminary inquiry on explosion from cast-iron steam-regulating valve chest at No. 3 Michael Colliery, East Wemyss, Fifeshire; explosion was caused by water-hammer action; claims that systematic inspection would have prevented this explosion.

Russian Instructions for Chemical Analyses of Boiler Feedwater and Control of Water Softening Apparatus. Izvestiya Teplotechnicheskovo Instituta (Moscow), no. 1 (34), 1928, pp. 82–93. Official text of Russian instructions for "complete" and "short" analyses of feedwaters, adopted on April 17, 1928. In Russian.

Advances in the Preparation of Boiler Water in the Years 1925–1927. Hofer Karl. Chem. Ztg. 52: 11; Fortschrittsber., 1928, 10–18. Chem. Abstracts, April 10, 1928, 22: 1201.—E. H.

Priming and Impurities in Feed Water. A. W. Ewell. Power, 67: 370–2, 1928. Chem. Abstracts, April 20, 1928, 22: 1420. Priming is increased by the presence of sugar, alkalies, and acids and decreased by suspended particles of boiler scale or of kaolin.—*D. B. Dill.*

Investigation of the Influence of Automatic Water-Level Regulators on Venturi Meters for Boiler-Feed Water. M. SCHAACK and H. LOHMANN. Apparatebau, **40**: 50–5, 1928; 11 cuts and 12 charts. Chem. Abstracts, May 20, 1928, **22**: 1816. Expts. with E. HANNEMANN's regulators "Direkt" are described in detail.—*J. H. Moore.*

Boiler Feed-Water Treatment from the English Viewpoint. D. BROWNLIE Power House (Toronto), **22**: 10, May 20, 1928, pp. 31–32 and 53, 1 fig. Some comments on progress throughout world; gigantic scheme of coöperative reseach on feedwater treatment is being carried out in United States; remedy for embrittlement; steel under stress.

Boiler Scale Prevention. A. T. RIDOUT. Machy. Market, (London), no. 2439, June 1, 1928, pp. 495–496. Physical system of treating water for boilers; by its use seawater may be used for make-up feed; system utilizes colloids; coagulation and absorption of colloids fairly important; treatment of linseed oil; elimination of oil in feedwater. Paper read before Institution of Marine Engineers.

Filtering and Softening Boiler Feed Water. H. M. MARSH. Power House (Toronto), **22**: 10, May 20, 1928, pp. 33–34, 4 figs. Use of sand filters or sand filters and zeolite water-softening filters for treating boiler feedwater; picks up impurities; bagging and blistering.

Latest Developments in Feedwater Treatment. D. BROWNLIE. Eng. and Boiler House Rev. (London), **41**: 11, May, 1928, pp. 533–534. Takes up problem of embrittlement; result of work in United States shows that embrittlement can only be caused when plates are in state of stress and when there is solution of caustic soda of more than 4000 grains per gallon; advantage of sodium phosphate and sodium tannate; in general, corrosion of boilers in stationary land practice is not such serious matter in Great Britain as in many other countries.

Steam Boiler Water Treatment. A. T. RIDOUT. Elec. Rev. (London), **102**: 2636, June 1, 1928, p. 967. Non-chemical method of preventing accumulation of scale in water-circulating systems by employment of true colloids, which it is claimed will enable seawater to be used for making-up boiler feedwater. Extracts from paper read before Institution of Marine Engineers.

Getting Good Results from a Filter. A. L. GOSNELL. Water Works, **67**: 6, June, 1928, p. 249. Practical suggestions; scraping filters; washing filters. Paper presented to Maryland Water and Sewerage Assn.

Developments in Water Filtration. J. R. BAYLIS. Can. Engr., (Toronto), **54**: 23, June 5, 1928, p. 588–590. Recent developments which have been made in treatment and filtration of water; recent practice in treatment of hard waters; outline of progress in water purification, giving few developments that stand out most prominently.

Eliminating Turbidity and Trade Wastes. G. E. Rickard. Water Works Eng., **81**: 11, May 23, 1928, pp. 671-672, 686, 689-690 and 693, 11 figs. Some of big filtration problems met by new Wheeling, W. Va., plant; unusual operating experiences; filtration plant was built for average consumption of 20,000,000 gallon; acidity and alkalinity; iron content of water; hydrogen-ion concentration and chlorides; bacteriological results; typhoid fever; saving under new system.

Filter Plant Operation Trials. W. H. Johnson. Can. Engr. (Toronto), **54**: 22, May 29, 1928, p. 575. Troubles met with at small plants discussed; superintendent must be versatile; operating troubles. Paper presented before Kentucky-Tennessee Section, American Water Works Association.

Steps in Laboratory Control by Modern Purification Plant. E. S. Hopkins. Water Works Eng., **81**: 10, May 9, 1928, pp. 636 and 639. Water examined to determine proper amount of chemicals needed and for bacteriological tests; systematic control required; tests determine plant efficiency; laboratory tests made daily.

Discoloration After Scraping: Contributory Causes and Remedies. Water and Water Eng. (London), **30**: 353, May 21, 1928, pp. 228-229. Scraping operations which led up to unsatisfactory conditions; summarizes probable remedies for causes already set out, each of which contributed towards trouble. Read before Institution of Water Engineers.

Pollution of Water Supplies. M. Z. Bair. Can. Engr. (Toronto), **54**: 22, May 29, 1928, p. 573. Various causes of contamination; groundwater supplies; emergency intakes; contamination from new mains; pollution from cross-connections; connections with private systems. Paper presented before Southwest Water Works Assn.

Drinking Water From Sea Water. E. T. Ellis. Dock and Harbour Authority (London), **8**: 87, January, 1928, p. 71. Preliminary processes; freezing out salt-free water; distillation at diminished pressure; low temperature distillation; high temperature distillation.

Elements of Successful Coagulation and Filtration. H. N. Jenks. Water Works, **67**: 5, May, 1928, pp. 203-206, 4 figs. Design features as related to coagulation; design of mixing devices; influence of plant design on filtration; design of underdrain system; size and depth of sand; depth of water in filter sand; filter-control equipment; effects of operating procedures on coagulation; filtration as affected by operating methods. Paper presented at Iowa Water Works Conference.

Water Purification. A. Houston. Chem. and Industry (London), **47**: 20, May 18, 1928, pp. 522-525, 11 figs. Author deals primarily with metropolitan water supply, London; notes pronounced beneficial effect of storage at

Chelsea reservoirs; gives illustrations exemplifying success of purification policy of Water Board; most of water is filtered through fine sand at slow rate of less than 2 gallons per square foot per hour; chlorination.

Qualities of Waters from Deep Wells. H. F. BLOMQUIST. Can. Engr. (Toronto), **54**: 23, June 5, 1928, pp. 583–584. Supplies from water-bearing formations more than 200 feet deep discussed; desirable qualities of water; sampling water at varying depths in wells; groundwaters vary widely. Paper presented at Water Works Conference.

Boiler Feed Water and Deep Wells. J. S. GANDER. Eng. and Boiler House Rev. (London), **41**: 11, May, 1928, pp. 528–530, 2 figs. London Basin is described as good geological illustration showing how pure water may be obtained from strata underlying large city; analysis of water obtained; methods of raising water from deep wells. (To be continued.)

Small Water Plant Starts Own Laboratory Test Works. F. E. TURNER. Water Works Eng., **81**: 10, May 9, 1928, p. 639. Results indicate that small purification plant will do well to establish own laboratory; tests are made each day to check operations. Abstract of paper read at Missouri Conference on Water Purification, Sedalia, Mo.

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CONTENTS

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*Col. J. T. Foster, Chicago, Ill.	1881–1882
*Col. J. T. Foster, Chicago, Ill.	1882–1883
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Standardization of Pipe Flanges and Fittings

FRANK A. BARBOUR, Hydraulic and Sanitary Engineer, 1120 Tremont Bldg. Boston, Mass.

Revision of Cast Iron Pipe Standards

FRANK A. BARBOUR, Hydraulic and Sanitary Engineer, 1120 Tremont Bldg., Boston, Mass.

Standardization of Fire Hose Coupling Thread

DENNIS F. O'BRIEN, A. P. Smith Manufacturing Co., East Orange, N. J.

Simplification and Standardization of Manhole Frames and Covers

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Specifications for Zinc Coating of Iron and Steel

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Topics and Personnel of Active Committees

Committee No. 1—Standard Methods of Water Analysis

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A. M. BUSWELL, Chief, State Water Survey Division, Urbana, Ill.

Dale L. Maffitt, Chemist, Des Moines Municipal Water Plant, Des Moines, Iowa.

Floyd W. Mohlman, Chief Chemist, Sanitary District of Chicago, 1014 So. Michigan Ave., Chicago, Ill.

(b) Bacteriological Methods

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Max Levine, Associate Professor of Bacteriology, Iowa State College, Ames, Iowa.

MacHarvey McCrady, Chemist & Bacteriologist, Board of Health of P. Q., 59 Notre Dame, East, Montreal, Canada.

John F. Norton, Department of Health Laboratories, Herman Kiefer Hospital, Detroit, Mich.

(c) Microscopical Methods

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(d) Field Representatives

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Linn H. Enslow, The Chlorine Institute, Inc., 30 E. 42nd St., New York, N. Y.

Sheppard T. Powell, Chemical Engineer, 213 St. Paul Place, Baltimore, Md.

Committee No. 2—Standards for Satisfactory Drinking Water—Work Completed.

Committee No. 3—Practicable Loadings for Purification Processes

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C. M. Daily, St. Louis Water Dept., St. Louis, Mo.

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Richard Messer, State Dept. of Health, Richmond, Va.

E. H. Read, Johns Hopkins University, Baltimore, Md.

F. Holman Waring, State Dept. of Health, Columbus, Ohio

Committee No. 4—Physical Chemistry in Relation to Water Purification—Work completed.

Committee No. 5—Watershed Protection—Work completed.

Committee No. 6—Industrial Wastes in Relation to Water Supply

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Committee No. 7—Pumping Station Betterments

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Committee No. 9—Standard Specifications for Cast Iron Pipe and Specials

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Committee No. 11—Sanitary Fountains—Work completed.

Committee No. 12—Testing of Water Works Materials and Supplies—Work completed.

Committee No. 13—Methods and Records of Water Waste Control—Work completed.

Committee No. 14—Committee on Meter Rates—Work completed.

Committee No. 15—Practical Standards of Rules and Regulations of Relations Between Water Works and Consumers—Work completed.

Committee No. 16—Essential Data for Water Records and Reports—Work completed.

Committee 17—Steel Pipe Lines—Work completed.

Committee No. 18—Filter Sand, Testing and Recording

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List of Publications Abstracted

Affiliated Engineering Societies of Minnesota—Bulletin
American Chemical Society—Journal
American City
American Electro-Chemical Society—Proceedings
American Forestry
American Medical Association—Annual Index
American Medical Association—Journal

American Meteorological Society—Publications
American Public Health Association—Journal
American Railway Engineering Association—Journal
American Society of Civil Engineers—Proceedings
American Society for Municipal Improvements—Proceedings
Board of Fire Underwriters—Reports
Boston Society of Civil Engineers—Journal
Canada Department of the Interior—Water Supply Bulletins
Canadian Engineer
Canadian Water Works Association—Journal
City Reports (Misc.)
Cleveland Engineering Society—Journal
Concrete
Connecticut Association of Civil Engineers—Proceedings
Dayton Engineers' Club—Publications
Engineering Association of the South—Proceedings
Engineering and Contracting
Engineering News-Record
Engineers' Club of Philadelphia—Journal
Engineers of St. Louis—Journal
Engineers' Institute of Canada—Journal
Engineers' Society of Western Pennsylvania—Proceedings
Franklin Institute—Journal
Illinois Society of Engineers—Reports
Illinois State Water Survey—Bulletins
Indiana Engineering Societies—Proceedings
Ingenieria Internacional (Published in New York)
Iowa Engineering Societies—Proceedings
Journal of Bacteriology
Journal of Biological Chemistry
Louisiana Engineering Society—Proceedings
Mechanical Engineering (Jour. Am. Soc. M. E.)
Missouri Water Works Association—Journal
Monthly Weather Review (U. S. Weather Bureau)
Municipal and County Engineering
New England Water Works Association—Journal
Ohio Engineering Societies—Proceedings
Ohio Water Works Association—Proceedings
Pennsylvania Water Works Association—Proceedings
Power
Power Plant Engineering
Public Health Engineering Abstracts (U. S.)
Public Utility Reports
Public Works
Railway Age
Railway Maintenance Engineer
Railway Mechanical Engineer

Railway Review
Scientific Lubrication
Southwestern Water Works Association—Journal
State Boards of Health—Reports and Bulletins (Misc.)
U. S. Bureau of Agriculture—Bulletins and Circulars
U. S. Bureau of Census—Statistics
U. S. Bureau of Mines—Bulletins, Circulars and Technical Papers
U. S. Bureau of Standards—Bulletins, Circulars, Technical Papers, etc.
U. S. Dept. of Agriculture—Bulletins and Circulars
U. S. Public Health Service—Reports, Bulletins and Reprints
U. S. Geological Survey—Water Supply Papers, Bulletins and Circulars
University Bulletins (Misc.)
Utah Society of Engineers—Proceedings
Water Works Engineering
Western Construction News
Western Society of Engineers—Journal

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OCTOBER 1, 1928

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CLAYTON, R. M. American Savings Bank, Atlanta, Ga........ Apr. 5, 1891
DONAHUE, COL. JAMES P. 520 Citizens Bank Bldg., Davenport, Ia.............................. Apr. 16, 1884
*EARL, GEORGE GOODELL. Gen. Supt., 402 Sewerage & Water Bd. Bldg., New Orleans, La.............. July 18, 1907
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ABBOTT, CARROLL B. President, Water Works Supply Co., 536 Call Bdg., San Francisco, Calif.............. May 24, 1922
*ABBOTT, G. H. Treas. and Supt., Southbridge Water Supply Co., Southbridge, Mass.............................. May 17, 1912
*ABSHER, C. W. Supt. City Water Dept., Mount Airy, N. C... Apr. 23, 1924
ACKERMAN, J. WALTER. City Manager, Watertown, N. Y.. Feb. 2, 1910
ACRES, H. G. Pres., H. G. Acres & Co., Cons. Engrs. Main & Ferry Streets, Niagara Falls, Ont.............. June 6, 1927
ADAMS, ALTON D. Box 88, Wellesley Hills, Mass........... Sept. 30, 1912
ADAMS, C. M. Municipal Engineer, Obras Publicas, Santo Domingo, R. D.............................. Apr. 23, 1927
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*AERYNS, ALBERT NELSON, C.E. 716 Greenwood Ave., Brooklyn, N. Y.............................. Jan. 18, 1915
*AGAR, E. W. Supt. Water Dept., Valparaiso, Ind.......... Mar. 16, 1927
ALBIN, W. W. Supt., Water Dept., San Diego, Calif........ June 6, 1927
ALEXANDER, R. C. Mgr., Water Co., Centerville, Iowa..... July 20, 1920

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ALLEN, C. D. 50 Lombard St., Toronto, Ont., Canada...... Apr. 29, 1924
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ALLEN, S. L. Georgetown, Ky. .... Jan. 19, 1924
ALLEN, THOMAS H. 1430 Bank of Commerce Bldg., Memphis, Tenn. .... Dec. 20, 1923
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ALLIN, T. D., C. E. 303 Kendall Bldg., Pasadena, Cal...... Mar. 28, 1910
ALPERS, FRANK H. Supt. Water Co., Cimarron, N. M....... Oct. 14, 1919
ALTOBERRO, JUAN CARLOS. Engr., Sub-Director de la Direccion de Saneamiento, 116 Cuareim St., Montevideo, Uruguay .... May 24, 1928
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*AMISS, THOMAS L. Supt. Water and Sewerage, Shreveport, La. .... May 14, 1918
*AMSBARY, F. C. Mgr. Water Co., Champaign, Ill. .... June 8, 1909
ANDERSON, A. L. Senior Civil Engineer, Construction Service, War Dept., Falls Church, Va. .... Nov. 10, 1925
*ANDERSON, J. R. Supt. Water & Light, Rutherfordton, N. C. .... Dec. 29, 1924
ANDERSON, L. M. Controller, Dept. of Water Power, 207 S. Broadway, Los Angeles, Calif. .... Nov. 24, 1924
*ANDERSON, ROBERT M. Prof. Engineering Practice, Stevens Institute, Hoboken, N. J. .... Dec. 22, 1916
ANDERSON, WILLIAM M. Chief Engineer, Bureau of Water Supply and Sewers, Honolulu, T. H. .... Apr. 30, 1928
*ANDREWS, GEORGE C. 932 Ellicott Sq. Bldg., Buffalo, N.Y. Feb. 28, 1917
ANDREWS, LEWIS P. Manager, Secy. and Treas. Water Co., Sedalia, Mo. .... Apr. 13, 1909
*ANDREWS, ROBERT E. National Board Fire Underwriters, 1014 Merchants Exchange Bldg., San Francisco, Calif. June 14, 1913
ANGUS, ROBERT W. Prof. of Mechanical Eng., University of Toronto, Toronto, Canada. .... Feb. 5, 1917
ANKENER, RICHARD. 140 12th Avenue, Long Island City, N.Y. .... Oct. 14, 1922
ANTWEILER, JOHN J. Assistant Engineer, 9013 Empire Ave., N. E., Cleveland, Ohio. .... June 6, 1927
*APPLEBAUM, SAMUEL BERNARD, C.E. Sanitary Engineer, 78 Stephenson Blvd., New Rochelle, N. Y. .... Apr. 24, 1916
ARCHER, ELMER T. Cons. Engr., New England Building, Kansas City, Mo. .... May 14, 1918
ARCHIBALD, J. G. Supt. Water Works System, Woodstock, Ont. .... Feb. 10, 1921
*ARMSTRONG, JAMES W. Filtn. Engr. City Water Dept., Lake Montebello, Hillen Road, Baltimore, Md. .... Mar. 12, 1910
*ARMSTRONG, KENNETH C. Chemist, Water Dept., Florence Pump Station, Omaha, Nebr. .... Dec. 29, 1924
ARMSTRONG, ROGER W. 172 Clinton St., Brooklyn, N. Y.... Apr. 8, 1916

ARNOLD, RUSSELL A., Bacteriologist, Frigidaire Corp., Dayton, Ohio........ Sept. 28, 1928
ATKINSON, ASHER. City Engr., 49 Mine St., New Brunswick, N. J........ Mar. 27, 1922
ATTERSALL, CHARLES F. Supt., Water Works, Winchester, Ky........ June 7, 1910
*AUSTIN, E. J. City Engineer, Hoquiam, Wash........ Nov. 23, 1927
*AUSTIN, R. N. Chf. Engr. & Mgr., Turbine Equipment Company, 73 King Street, West, Toronto, Canada.... May 12, 1925
AVERY, CHARLES NEEDHAM. Commissioner, Water, Light & Power, Austin, Texas........ May 28, 1924
*AVERY, ELWOOD. Consulting Engineer, 15–17 Masonic Temple, Harrisburg, Pa........ Feb. 28, 1922
*AXE, EARL J. Chemist, Bureau of Water, 16 So. Ann St., Lancaster, Pa........ Apr. 26, 1926
*AYRES, LOUIS E., C.E., B.S. Ayres, Lewis, Norris & May, Cornwell Building, Ann Arbor, Mich........ Nov. 16, 1916

*BABBITT, HAROLD E. 204 Engineering Hall, Urbana, Ill..... June 4, 1915
BABCOCK, G. H. Supt. Water Works, East Rochester, N. Y... June 7, 1916
*BACHARACH, E. W. Pres., E. W. Bacharach and Co., 616–17 Rialto Bldg., Kansas City, Mo........ Apr. 29, 1924
*BACHMANN, FRANK. Dorr Co., 310 So. Michigan Ave., Chicago, Ill........ Feb. 4, 1915
BADGER, H. F. Secretary, Board of Fire Und. of the Pacific, 914 Merchants Exchange Bldg., San Francisco, Calif.. Aug. 1, 1925
BADLEY, HARRY W. Water Supt., 1123 N. Carroll St., Carroll, Iowa........ May 22, 1928
BADO, ATILIO A. Pueyrredon 1127, Buenos Aires, R. A..... Nov. 6, 1924
*BAHLMAN, CLARENCE. Chief Bacteriologist Cincinnati Filtration Plant, California, Ohio........ Feb. 7, 1922
*BAIN, ERNEST B. Supt., City Water Dept., Raleigh, N. C... June 1, 1904
*BAITY, H. G. Assoc. Prof. School of Engineering University of N. C., Chapel Hill, N. C........ May 15, 1923
*BAKER, CLARENCE M. 2 S. Carroll St., Madison, Wis....... Oct. 4, 1915
*BAKER, GERALD C. 208 Hanssler Place, Peoria, Ill........ Mar. 17, 1925
*BAKER, HAROLD W. C. E., Comnr., Dept. of Public Works, Rochester, N. Y........ Jan. 31, 1922
*BAKER, M. N. Assoc. Editor, Engineering News-Record, 10th Ave. at 36th St., New York, N. Y........ June 24, 1903
*BALDWIN, F. O. Supt. Water Purification Plt., Westover Hills, Richmond, Va........ May 10, 1922
*BALDWIN, HERBERT B., Chemist, Dept. of Health, 927 Broad St., Newark, N. J........ Mar. 27, 1919
*BALDWIN, ROBERT LEE. Cons. Engr. Burns & McDonnell, Engr. Co., 402 Interstate Bldg., Kansas City, Mo..... Nov. 20, 1925
*BALDWIN, ROBERT T. Sect., Chlorine Institute, Inc., 52 E. 41st St., New York, N. Y........ July 28, 1924
BALL, EDMUND BRUCE. "Braemar" Ayr, Scotland........ Jan. 26, 1924
BALLOU, ARTHUR FRANCIS. Engr. Natl. Board of Fire Underwriters, 85 John St., New York, N. Y........ Aug. 7, 1924
BANK, WILLIAM G. Asst. Engr., Bureau of Water, Newark, N. J........ Dec. 16, 1919
BANKS, HOWARD C. Supt. of Water Works, Wildwood, N. J. May 11, 1927
*BANKSON, ELLIS E., C. E. Clark Bldg., Suite 813, Pittsburgh, Pa........ July 27, 1922
*BANTEL, E. C. H. Prof. of Civil Eng., Univ. of Texas, 2307 San Antonio St., Austin, Texas........ Apr. 23, 1927

*Barbour, Frank A. Hydraulic & Sanitary Engr., 1120 Tremont Bldg., Boston, Mass. May 21, 1906
*Barclay, Herbert T. Superintendent Water Works, Water Department, City Hall, Kansas City, Kans. July 22, 1926
Barclay, W. E. Supt. Dept. Water and Elect., Aurora, Ill. May 13, 1918
*Bardwell, C. M. Assistant Water Engineer, Missouri-Kansas-Texas R. R. Co., 2609 Grim St., Waco, Texas. July 6, 1926
*Bardwell, R. C. 3211 Hanover Ave., Richmond, Va. Nov. 3, 1916
Barker, J. R. Pacific Coast Manager, Neptune Meter Co., 320 Market St., San Francisco, Cal. June 15, 1926
Barnard, W. K. 704 Central Bldg., Los Angeles, Calif. Oct. 31, 1923
*Barnes, George E. Assoc. Prof., Civil Engineering, University of Florida, Gainesville, Fla. Feb. 24, 1928
*Barnes, W. V. Borough Engr., Dept. Water Supply, Gas & Elec., Borough Hall, Staten Island, N. Y. Feb. 26, 1926
*Barnett, A. G. 337 Fond du Lac St., Waupun, Wis. Apr. 30, 1923
Barnett, C. P. Consulting Engineer, Covington, Virginia. June 13, 1922
*Barnhard, P. Mgr., Mt. Carmel Public Utility Co., Mt. Carmel, Ill. Oct. 19, 1914
Barns, Frederick B. Helling-Barns, Inc., 151 East 21st St., New York, N. Y. Mar. 14, 1922
*Barnum, Edmund Kirby. Engr., Fresno City Water Corp., Fresno, Calif. Mar. 31, 1925
*Barr, William M. Consulting Chemist, Union Pacific Systems, Omaha, Neb. Feb. 9, 1917
*Barrick, M. J. 1603 Junction St., South Williamsport, Pa. Feb. 16, 1924
Barron, A. F., Dist. Mgr., Simplex Valve & Meter Co., 30 No. Michigan Ave., Chicago, Ill. Sept. 24, 1928
*Barstow, E. D. Barstow & McCurdy, Inc., 322 Ohio Bldg., Akron, Ohio. Sept. 27, 1927
Bartlett, N. Emory. Natrona Water Co., 1000 Widener Building, Philadelphia, Pa. June 7, 1909
*Bartlett, Terrell. Cons. Engr., 612 Cacasieu Bldg., San Antonio, Tex. June 8, 1923
Bartley, Robert, Supt., Dept. Water & Sewers, Box 377, Asbury Park, N. J. Mar. 8, 1924
*Bartow, Col. Edward. Chemistry Dept., State Univ. of Iowa, Iowa City, Ia. June 7, 1909
*Bartram, George C. 847 Ellicott Square Bldg., Buffalo, N. Y. June 7, 1921
Bartuska, James F. Supt. Water Dept., 288 Cleveland Ave., Whiting, Ind. Oct. 14, 1924
*Basom, G. E. Supt., Water & Light Commission, Fairmont, Minn. June 6, 1927
*Bass, Frederick H. 429 Union St., Minneapolis, Minn. Apr. 2, 1909
Bassett, Carrol P., C.E. Summit, N. J. Oct. 14, 1909
Bassett, Charles K., M.E., Buffalo Meter Co., 2917 Main St., Buffalo, N. Y. June 13, 1921
Bassett, Geo. B., C.E. 691 W. Ferry St., Buffalo, N. Y. Apr. 12, 1909
*Batchelder, George W. Water Commissioner, 19 City Hall, Worcester, Mass. Apr. 25, 1916
*Bates, Clinton O. Analytical & Consulting Chemist, Cedar Rapids, Ia. July 17, 1922
*Bates, Ralph D. State Dept. of Health, 23 S. Pearl St., Albany, N. Y. Feb. 10, 1921
*Baton, Warren U. C. Chief Analyst, 528 S. Lang Ave., Pittsburgh, Pa. Apr. 9, 1909
*Batt, John B. Supt. Water Works, North Tonawanda, N. Y. Apr. 24, 1919

Baudouin, Oscar, C.E. 71A St. James Street, Montreal, Canada ... June 8, 1925
Bauereisen, R. J. 9 South Clinton St., Chicago, Ill. ... Aug. 8, 1915
Bauman, James A. Chemist, Analytical & Clinical Laboratory, 164 W. Ridgewood Ave., Ridgewood, N. J. ... Aug. 6, 1928
Bayha, Chas. L. Superintendent Water Works, Box 536, Whitefish, Mont ... June 30, 1926
Bayley, Edgar A. Asst. Engr. Dept. of Water & Power, 207 So. Broadway, Los Angeles, Calif ... June 1, 1928
*__Baylis, John R.__ 1643 E. 86th St., Chicago, Ill ... Oct. 2, 1915
*__Beal, R. B.__ Chemist, The Flox Company, 117—27th Ave., S. E., Minneapolis, Minn ... June 6, 1927
*__Bean, Elwood L.__ Chemist, Providence Water Works, 19 Redwing St., Providence, R. I ... Apr. 6, 1928
Bean, George L. Civil Engineer, 1729 N. 19th St., Philadelphia, Pa ... Dec. 29, 1913
Beasley, W. S. Agent, Dutchess Bleachery, Inc., Wappingers Falls, N. Y ... Jan. 7, 1927
Beck, Frederic E. J. G. White & Co., Inc., 37 Wall St., New York, N. Y ... Apr. 20, 1915
Becker, Charles H. Mgr., Hydrant & Valve Department, R. D. Wood & Co., 400 Chestnut St., Philadelphia, Pa ... Aug. 25, 1927
*__Beckett, Richard C.__ San. Engr., Delaware State Hlth. Dept., 205 N. State St., Dover, Del ... Sept. 27, 1924
Bedell, Arthur S. Elsmere, New York ... June 10, 1920
*__Bedell, James.__ Supt., Water Works, 10 Croton Ave., Ossining, N. Y ... May 12, 1908
Beebe, J. D. Dist. Mgr., Oregon-Wash. Water Service Co., 304 So. Commercial St., Salem, Ore ... Jan. 26, 1928
*__Beech, F. B.__ Gen. Supt., 101 Island Ave., McKees Rocks, Pa ... Jan. 5, 1925
*__Beers, William H., Jr.__ Box 116, Gatun, Canal Zone ... Sept. 12, 1922
*__Beeson, F. M.__ Graver Corp., 808 Pacific Natl. Bank Bldg., Los Angeles, Calif ... Oct. 27, 1925
*__Behrman, A. S.__ Chf. Chemist, International Filter Co., 333 W. 25th Pl., Chicago, Ill ... Feb. 28, 1925
*__Beisel, N. J.__ Gen. Mgr., Pottsville Water Co., 221 S. Center St., Pottsville, Pa ... July 31, 1924
Belcher, Richard. Prest. Water Co., Marysville, Cal ... Oct. 4, 1919
*__Bell, David V.__ Supt., Water Companies, U P R R Co., U. P. Coal Co. Bldg., Room 102, Rock Springs, Wyo ... May 14, 1909
*__Bell, H. K.__ Civil Engr., 372 Transylvania Park, Lexington, Ky ... Jan. 16, 1924
Belyea, Chas. L. Water Works Supt., 741 Queen St., East, Sault Ste. Marie, Ont ... Feb. 28, 1928
*__Bemis, Edward W.__ 332 S. Michigan St., Rm. 601, Chicago, Ill ... May 18, 1909
*__Benedict, Sydney J.__ Asst. Engr., Bureau of Water, 211 City Hall, Portland, Ore ... Dec. 8, 1928
Bennett, Frank U. Supt., Municipal Water Plant Melbourne, Fla ... May 17, 1928
Benton, L. J. Supt. Water & Light Dept., Fremont, N. C ... Dec. 8, 1923
*__Bernhagen, Lewis O.__ City Hall, Beaumont, Tex ... Mar. 6, 1917
*__Berrino, Juan B.__ Ingeniero Civil, Paraguay 3690, Buenos Aires, R. A ... Aug. 5, 1927
*__Berry, Albert E.__ 235 Gainsborough Road, Toronto, Ont., Can ... June 21, 1920
Berry, F. R. Engr. Am. W. W. & E. Co., 50 Broad St., New York, N. Y ... Apr. 20, 1923

BERRY, FRED D. Sec. Bd. Water Comrs., Hartford, Conn.... Mar. 20, 1918
BERRYHILL, R. M. City Engineer, Tulare, Calif............ July 31, 1928
*BESSELIEVRE, E. B. Sanitary Engineer, Dorr Company, Inc., 247 Park Ave., New York, N. Y.......... Oct. 7, 1919
BEST, OSCAR V. Asst. Supt., Water Dept., 1020 Martin St., Jackson, Mich.......... July 14, 1928
*BETTES, CHARLES R. Long Island Water Corp., Far Rockaway, L. I. N. Y.......... June 18, 1901
*BIGGS, GEORGE W., Jr. Chf. Engr. Amer. Water Works and Elect. Co., 50 Broad St., New York, N. Y.......... June 2, 1916
*BILLINGS, LLOYD C. Supt. Filtn. Plant, 1247 Bemis St., S. E., Grand Rapids, Mich.......... May 23, 1923
*BIRD, BYRON. Municipal & Sanitary Engineer, 1602 Second Ave., North, Fort Dodge, Iowa.......... July 31, 1924
BIRD, CYRUS R. The Pitometer Co., 906 Majestic Bldg., Detroit, Mich.......... Mar. 16, 1922
*BIRDSALL, LEWIS I. General Chemical Co., 300 W. Adams St., Box 3, Chicago, Ill.......... June 24, 1913
BISER, D. BENTON. Asst. C. E., Water Dept. City Hall, Baltimore, Md.......... Sept. 27, 1923
BISHOP, GUY H., C.E. Carolina Engineering Co., P. O. Box 1288, Charlotte, N. C.......... Sept. 26, 1921
BISHOP, J. W. Supt., Ithaca Water Dept., City Hall, Ithaca, N. Y.......... Apr. 30, 1928
*BISHOP, WESLEY. 275 W. Main St., Moorestown, N. J...... Mar. 29, 1916
*BLACK, ERNEST B. Cons. Engr., Mutual Building, Kansas City, Mo.......... June 24, 1913
BLACK, GURDON G. 414 N. Union Blvd., St. Louis, Mo....... Feb. 13, 1915
BLACKWELDER, C. D. Post Box 266, Greenville, S. C........ May 18, 1926
BLAIN, CLAUD FRANCIS. Public Works Department, Sydney, N. S. W., Australia.......... Nov. 14, 1922
BLAIR, HOMER O. 1104 Pacific Ave., Pacific Savings Bldg., Tacoma, Wash.......... Aug. 17, 1925
*BLAIR, T. J., JR. 16 S. Main Ave., Weston, W. Va.......... Apr. 23, 1924
*BLAISDELL, HIRAM W. Filtration Engineer, Maidstone Apartments, 1327 Spruce St., Philadelphia, Pa. .... Sept. 24, 1925
BLAKEMAN, S. R. Supt., Water & Light Plant, Dyersburg, Ten.......... Jan. 31, 1927
BLANCHARD, R. K., M.E. Neptune Meter Co., 50 East 42nd St., New York, N. Y.......... June 19, 1919
BLEISTEIN, BERNARD J. Asst. Engr., Dept. W. S., Gas & Elec., N. Y. C., 162 Lefferts Ave., Brooklyn, N. Y...... Apr. 26, 1918
*BLESSED, WILLIAM S. Mech. Engr., 800 Marquette Bldg., Detroit, Mich.......... June 1, 1923
BLEVINS, WILLIAM H. Mgr., Kentucky Utilities Co., Mt. Sterling, Ky.......... Jan. 16, 1924
*BLEW, MICHAEL JAMES. Research Engineer, Bureau of Engr., Department of Public Works, N. E. Dept., Richmond St. & Wheatsheaf Lane, Philadelphia, Pa.......... Aug. 21, 1922
BLIVEN, CHARLES H. Supt. Norfolk City Water Dept., Norfolk, Va.......... May 12, 1914
*BLIVEN, GEO. H. 310 Powers Bldg., Rochester, N. Y...... Apr. 26, 1909
BLIVEN, JESSE A. Supt. New York Water Service Corp., 9002 91st Ave., Woodhaven, N. Y.......... Mar. 24, 1926
BLIVEN, M. HARVEY. 71 Bellevue Drive, Rochester, N. Y... Apr. 12, 1921
*BLOHM, ARTHUR W. P. Asst. San. Engr. State Dept. of Health, 2206 Walbrook Ave., Baltimore, Md.......... Aug. 9, 1922
*BLOMQUIST, H. F. Supt. City Water Works, Cedar Rapids, Ia.......... May 13, 1917

Blossom, Francis. Engineer, 52 William St., New York, N. Y.	Apr. 9, 1906
*Boardman, W. H. Civil Engr., 426 Walnut St., Philadelphia, Pa.	Apr. 18, 1909
Bodkin, J. T. St. Joseph Water Co., St. Joseph, Mo.	Mar. 19, 1924
*Bogert, Clinton L. Consulting Engineer, 30 Church St., Rm. 414, New York, N. Y.	Jan. 19, 1924
*Bohmann, Henry P. Supt. Water Works, Milwaukee, Wis.	May 8, 1913
Bolton, James R. Supt. of Water Dept., City Hall, 20 Gerald Ave., Highland Park, Mich.	Mar. 25, 1924
*Booker, Warren H. 1014 Queens Road, Charlotte, N. C.	July 21, 1911
Booth, George W. 85 John St., New York, N. Y.	Feb. 2, 1924
*Booth, L. M. Prest. Booth Chemical Co., P. O. Box 203, Elizabeth, N. J.	May 12, 1914
*Booth, William Miller. Cons. Chem. Engr., 526 University Bldg., Syracuse, N. Y.	June 8, 1909
Borden, Moro M. 310 Lees Ave., Collingswood, N. J.	June 5, 1912
*Boruff, C. S. 208 W. Iowa St , Urbana, Ill.	June 17, 1925
Botten, H. H. Chief Engr., Washington Surv. & Rating Bur., P. O. Box 1818, Seattle, Wash.	Jan. 16, 1924
*Bovard, Paul F. Asst. Mgr., Sect. & Treas., California Filter Co., Inc., 618 Merchants Exchange, San Francisco, Calif.	Aug. 12, 1926
*Bowe, Thomas Francis. Cons. Engr., 110 William St., New York, N. Y.	Feb. 9, 1920
Bowen, Edward R. Reaburn & Bowen, Cons. Engineers, 1104 Central Bldg., Los Angeles, Calif.	July 20, 1925
Bowers, H. S. Superintendent of Filtration, R. F. D., Denbigh, Va.	Aug. 28, 1926
*Bowers, Herbert L. Paige & Jones Chemical Co., 80 Marble St., Hammond, Ind.	Oct. 13, 1926
*Bowman, Abraham M. Supt. Public Utilities, Elmira, Ont.	Oct. 21, 1919
*Bowne, Sidney B. Civil Engineer, Mineola, N. Y.	May 28, 1924
*Boyce, Earnest. Chief Engineer & Director, Division of Water & Sewage, State Board of Health, Lawrence, Kans.	Apr. 13, 1926
*Boyle, Bryan J. Wtr. Comnr. 2 Municipal Bldg., Buffalo, N. Y.	Mar. 16, 1922
Boyle, Edward C. General Delivery, McAllen, Texas.	Apr. 12, 1916
*Boyles, Marvin M. Engr., Water & Sewer Dept., City Hall, Greensboro, N. C.	Sept. 26, 1921
*Boynton, Perkins. 624 Locust Ave., Clarksburg, W. Va.	June 16, 1920
*Bradbury, Edward Gatling. County Sanitary Engr., Court House, Columbus, O.	June 16, 1919
*Bradley, J. F. Chf. Engr. & Bact., R. F. D. 8, Valparaiso, Ind.	Feb. 10, 1921
Bradshaw, Campbell, Editor, "Engineering Times," 933 Bay St., Toronto, Ont.	Mar. 26, 1928
Bragg, George H. 445 Sutter St., San Francisco, Cal.	Oct. 14, 1922
Brakenridge, C. City Engineer, City Hall, Vancouver, B. C., Can.	Nov. 8, 1923
*Brandis, Fred E. Supt., Municipal Water Works, Blaine Co., Chinook, Mont.	Mar. 13, 1925
*Brantly, E. C. Mgr., Water, Gas & Electric Depts., Danville, Va.	Feb. 21, 1927
Breen, Peter J. Supt. Water Works Dept., Calgary, Alberta, Canada.	Mar. 16, 1927
*Breitzke, Charles F. 412 William St., Boonton, N. J.	June 7, 1910

*BRENSLEY, ALBERT A. c/o Suhr, Berryman, Peterson & Suhr, 130 N. Wells St., Chicago, Ill. Mar. 13, 1928
*BRETZ, C. E. Supt. City Water Works, City Hall, Oklahoma City, Okla. Aug. 1, 1923
BRICKENDEN, F. M. Asst. Engr., Dept. of Health—Water Purif., 301 Huron St., London, Ont. June 29, 1928
*BRICKER, R. P. Pres., Shelby Water Co., Shelby, Ohio. Nov. 19, 1915
BRIDGERS, J. H. Pres. Henderson Water Co., 123 N. Garnett St., Henderson, N. C. June 5, 1923
*BRITAIN, WM. PERRY. Supt., City Water & Light Plant, West Plains, Mo. Nov. 12, 1926
BROOKS, JOHN N. 339 Bellevue Ave, Trenton, N. J. Feb. 24, 1912
BROOKS, THOMAS. Supt. Domestic Distribution, Water Department, 2045 N. Catalina St., Los Angeles, Calif. Sept. 10, 1925
*BROSSMAN, CHARLES. Cons. Engr., 1010 Chamber of Commerce Bldg., Indianapolis, Ind. Apr. 7, 1916
BROWER, I C. City Manager, Lima, Ohio. Apr. 18, 1915
BROWN, C. ARTHUR. Sanitary Engineer, West Erie Ave., R. F. D. 2, Lorain, O. June 27, 1905
BROWN, C. D. Mgr. The Walkerville Water Co., Walkerville, Ontario, Can. Oct. 16, 1916
BROWN, CALVIN S. The Belvedere. Toledo, Ohio. Mar. 15, 1882
*BROWN, PROF. CHARLES CARROLL, University Engr. Dept., Gainesville, Fla. May 12, 1906
BROWN, EDWARD. Supt. Water Works, Eau Claire, Wis. Jan. 24, 1921
*BROWN, HORACE A., C.E. Cons. Engr. and Supt. Water Works, Ottumwa, Iowa. May 7, 1919
BROWN, JAMES. Supt., Water Works, 425 East Olive St., Turlock, Calif. Sept. 12, 1922
*BROWN, KENNETH W. Sanitary Engineer, California Water Service Co., Stockton, Calif. July 11, 1927
BROWN, RASSELAS W. Supt. and Secty., Corry Water Supply Co., Corry, Pa. Apr. 3, 1916
BROWN, W. C. Supt., San Diegnito Irrigation Dist., Encinitas, Calif. June 11, 1928
*BROWNE, FLOYD G. Supt. & Chemist, Sewage Treatment Works, 513 Delaware Ave., Marion, Ohio. June 5, 1926
BRUCE, JOHN A. Consulting Engineer, Bankers Reserve Life Bldg., Omaha, Nebr. Oct. 21, 1920
BRUMBY, J. R., JR. Commissioner of Public Works, Sarasota, Fla. Apr. 11, 1928
*BRUSH, FREDERICK CLINTON. Mgr. Bound Brook Water Co., 519 Watchung Road, Bound Brook, N. J. Jan. 7, 1924
*BRUSH, WM. W. Chief Engineer, Dept. Water Supply, Gas and Electricity, Municipal Bldg., Rm. 2456, New York, N. Y. Feb. 18, 1911
BUCHANAN, ALBERT MILLAR. Engr., Gartshore-Thomson Pipe & Fdy. Co. Ltd., Hamilton, Ont., Canada. June 17, 1926
BUCHANAN, EDWARD VICTOR. Gen. Mgr., Public Utilities Comn., London, Ont., Canada. Apr. 29, 1926
BUCHANAN, HUGH. Compania Consolidada de Aguas, Corrientes del Rosario, Ltda., Rosario de Santa Fe, A. R. June 25, 1924
BUCHANAN, JOHN H. Prof. Sanitary Chemistry, Iowa State College, Ames, Iowa. May 26, 1927
*BUCK, GEORGE H. Asst. Engr., with Nicholas S. Hill, Jr., 260 W. Jersey St., Elizabeth, N. J. Jan. 28, 1926
BUCK, WILLIAM H. Engr. and Supt. Construction, Riverton & Palmyra Water Co., Riverton, N. J. May 7, 1916

BUCKELS, J. C. Supt., Water Works, Kissimmee, Fla........ Apr. 16, 1928
*BUELL, WM. C. Gen. Mgr., Millville Water Co., High St., Millville, N. J........ June 17, 1926
*BUGBEE, ALVIN. Supt. Trenton Water Dept., City Hall, Trenton, N. J........ Dec. 9, 1925
*BUGBEE, JULIUS W. City Chemist, 290 Massachusetts Ave., Providence, R. I........ Feb. 20, 1924
*BUHRENDORF, JOHN C. C.E., 74 Fairview Ave., Yonkers, N. Y........ Mar. 25, 1924
BULL, CHARLES H. Asst. Engr., Dept. W. S. G. & E., 702 Madison Ave., New York, N. Y........ Mar. 30, 1920
*BULL, IRVING C. Analytical and Consulting Chemist, 50 West St., New York, N. Y........ June 8, 1906
*BULLARD, J. L. Supt., Water, Light & Power Plant, Drawer 598, Lexington, N. C........ Aug. 26, 1925
*BULLOCK, DE WITT H. Supt. of Water System, 80 Walnut St., Canajoharie, N. Y........ Jan. 1, 1928
*BUNKER, GEORGE CYRUS. P. O. Box 5035, Ancon, C. Z........ Feb. 23, 1911
BUNTING, P. G. R. D. Wood & Co., Box 11, Petersburg, Va. Feb. 7, 1916
BUNTING, S. A., M. A., B. Sc., Duncan, Stratton & Co., 5 Bank St., Bombay, India........ Dec. 20, 1927
*BURCHARD, EDWIN DAY. Dist. Engr., U. S. Geol. Survey, 316 Jackson Bldg., Asheville, N. C........ Jan. 5, 1925
*BURDICK, CHARLES B. Hydraulic and Sanitary Engr., 1417 Hartford Bldg., Chicago, Ill........ July 18, 1907
*BURGESS, PHILIP. Cons. Engr., 568 East Broad St., Columbus, Ohio........ Apr. 27, 1911
BURNETT, MUSCOE. Prest. Water Co., Paducah, Ky........ June 22, 1923
BURNHAM, HARRY A. Engr. & Sp. Insptr. F. M. F. Ins. Co., 68 Brookside Ave., Newtonville, Mass........ June 16, 1920
BURNIE, ARTHUR N. Vice President & Treasurer, Beaver Valley Water Co., 1006—7th Ave., Beaver Falls, Pa........ Mar. 22, 1916
BURT, JOHN. Gnl. Mgr. Marin Mcpl. Wtr. Works, 425 5th Ave., San Rafael, Cal........ May 20, 1920
*BURT, L. B. National Lime Association, 927-15th St., N. W., Washington, D. C........ July 31, 1924
*BUSHNELL, LYMAN S. Chief Chemist, Freeport Sulphur Co., Freeport, Texas........ Mar. 10, 1928
BUSTELO, FRANCISCO. Engr., Water Works of Murcia & Cartagena, Gran Hotel, Cartagena, Spain........ May 31, 1928
*BUSWELL, A. M. Chief, State Water Survey Divn., Urbana, Ill........ Mar. 20, 1916
BUTLER, F. W. W. Water Engineer's Dept., Durban, Natal, South Africa........ May 17, 1927
BUTZ, GEORGE W., SR. 2301 Boulevard, Wilmington, Del.... Nov. 20, 1923
BUZBY, J. S. Box 310, Burlington, N. J........ Sept. 30, 1919

*CADMAN, ROBERT M. 244 Cambridge Ave., Red Bank, N. J. May 28, 1924
*CAIRD, JAMES M. Chemist & Bacteriologist, Cannon Bldg., Broadway & 2nd St., Troy, N. Y........ May 16, 1900
CALDWELL, JAMES H., C.E. 55 First St., Troy, N. Y........ July 10, 1906
CALHOUN, J. W. Meter Foreman, New Chester Water Co., Box 264, Chester, Pa........ May 14, 1921
*CALVERT, CECIL K. Chemist, Indpls. Sewage Comn., 1902 N. New Jersey Ave., Indianapolis, Ind........ Nov. 22, 1920
CAMERON, ARCHIBALD PRESTON. c/o Worthington-Simpson, Ltd., Queens House, Kingsway, London, W. C. 2, Eng. June 4, 1912
CAMPBELL, C. B. Supt., Bureau of Water, Altoona, Pa.... May 10, 1915

*Campbell, Elmer W. State Dept. of Health, Augusta, Maine. Dec. 8, 1923
Campbell, George A. P. O. Box 2002, Reno, Nev.......... Apr. 9, 1913
*Campion, Harry T. 142 Orchard Ave., Barberton, Ohio... Nov. 30, 1920
*Cannen, James V. Civil Engr., 1200 Hamilton Blvd., Hagerstown, Md.......... Mar. 27, 1925
*Cannon, J. W. Supt., Water Works, Fort Lauderdale, Fla... Mar. 22, 1928
Capron, John D. Statistical Engineer, U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.......... Jan. 30, 1924
*Carlin. Phil. Supt. Water Works, Sioux City, Iowa....... Apr. 14, 1891
Carpenter, George D. Water Commissioner, City Hall, Ithaca, N. Y.......... Apr. 30, 1928
*Carpenter, Lewis V. Asst. Prof. Sanitary Engineering, West Virginia University, Box 562, Morgantown, W. Va. June 28, 1926
*Carr, J. A. Supt., Water Dept., Ridgewood, N. J.......... May 3, 1916
*Carrick, O. W. Wtr. Engr., Wabash Ry., 1636 E. William St., Decatur, Ill.......... Sept. 21, 1920
Carroll, Eugene. Vice Prest. and Mgr. Butte Water Co., Butte, Mont.......... June 7, 1904
Carson, H. Y. Research Engineer, American Cast Iron Pipe Co., Birmingham, Ala.......... July 6, 1926
Casad, Charles C. City Engineer & Supt. Water Dept., City Hall, Bremerton, Wash.......... Jan. 25, 1926
Casad, Orla. Superintendent Water Works, Box 624, Merced, Calif.......... Nov. 6, 1924
Cascadden, Albert. Supt. Power Plant, 1818½ Stone St., Port Huron, Mich.......... May 11, 1927
*Case, Egbert D. Vice-Pres., Pitometer Co., 50 Church St., New York, N. Y.......... Mar. 4, 1921
*Case, H. R. Mgr. Corona City Water Co., 707 Main Street, Corona, Calif.......... May 28, 1926
Casgrain, Charles P. Mgr., Water Works, City Hall, Quebec, Canada.......... May 20, 1920
Cashmore, H. D., Jr. Asst. Sanitary Engineer, U. S. Public Health Service, 420 Call Bldg., San Francisco, Calif... June 29, 1928
Castro, Ramon. Gen. Mgr., Bucaramanga Waterworks Co., Bucaramanga, Colombia, S. A.......... June 30, 1928
Cates, R. H. Pwr. Engr., So. Cal. Edison Co., P. O. Box 135, Los Angeles, Cal.......... June 16, 1920
Caton, F. E. Mgr. Water Dept., Princeton, Ind.......... June 6, 1927
*Caughey, J. E., C. E. Supt., Water Works Dept., Wallaceburg, Ont.......... Mar. 28, 1928
Cauthorn, Chowning. City Mgr., Palatka, Fla.......... May 17, 1928
*Cecil, Lawrence K. Sales Engr., International Filter Co., 209 Commercial Bldg., Tulsa, Okla.......... Jan. 31, 1928
Center, John L. Superintendent Water Works, 64 Hypolita St., St. Augustine, Fla.......... Jan. 25, 1927
*Chamberlain, L. H. 706 Wright & Callender Bldg., Los Angeles, Calif.......... Jan. 2, 1924
Chamberlain, William J. Chief Chemist, Metropolitan Water Supply & Sewerage Board, Albert St., Brisbane, Queensland, Australia.......... Dec. 23, 1927
Chamberlin, R. B. Chief Chemist, By-Products Coke Corp., 11233 Torrence Ave., South Chicago, Ill.......... Aug. 14, 1928
*Chambers, George H. Supt. Mntnce., B. of W., 50 Lake View Ave., Buffalo, N. Y.......... June 8, 1921
Chambers, John. Chief Engr. and Supt., Louisville Water Co., Louisville, Ky.......... June 8, 1921
*Chamot, E. M. Prof. Sanitary Chemistry, Cornell University, Ithaca, N. Y.......... Feb. 13, 1915

*Champe, George, C. E. 710 Securities Bank Bldg., Toledo, Ohio.......... Mar. 10, 1913
Champion, Roy B. Supt. Public Works, 36 West 12th St., Holland, Mich.......... Mar. 11, 1914
*Chapman, F. W. Supt. Water Works, Camden, S. C.......... Dec. 5, 1925
*Chapman, William J. Supt., Hudson Water Service Corp., 10 Maple Ave., Haverstraw, N. Y.......... Mar. 22, 1927
*Charter, A. Supt., Municipal Light & Water Plant, Covington, Tenn.......... Sept. 18, 1926
*Chase, Charles P., C.E. 123 Sixth Ave., Clinton, Ia.......... Aug. 31, 1916
*Chase, Edward Sherman. c/o Metcalf and Eddy, 1300 Statler Bldg., Boston, Mass.......... May 3, 1919
Chase, Horace H. 610 West 146th St., New York, N. Y.......... May 28, 1924
Chase, John H. Hydraulic Engineer, Box 602, Riverside, Calif.......... Nov. 10, 1928
Chase, Richard D., C.E. 607 Purchase St., New Bedford, Mass.......... Nov. 3, 1919
Chenery, Christopher T. Pres., Federal Water Serv. Corp., 27 William St., New York, N. Y.......... June 17, 1926
Cherry, B. F. Mgr., Weatherford Water, Light & Ice Co., Weatherford, Texas.......... Feb. 28, 1925
*Chester, J. N., H. and M. E. Clark Bldg., Suite 813, Pittsburgh, Pa.......... Nov. 7, 1910
*Chinn, Keith R. P. O. Box 3113, West Palm Beach, Fla.......... Feb. 23, 1927
*Chipman, Willis, C.E. Mail Bldg., Toronto, Ont., Can.......... Apr. 18, 1888
Chisham, J. M. Supt. Water Co., Atchison, Kans.......... June 11, 1902
Chisholm, R. B. F. California Water Service Co., 414 Hunter-Dulin Bldg., San Francisco, Calif.......... July 11, 1927
Chivvis, Leland. 1437 McCausland Ave., St. Louis, Mo.......... Oct. 4, 1919
Christensen, C. H. Mgr. Lt. & Water Co., Missoula, Mont. Oct. 4, 1919
*Christman, C. H. Chemist, Bryson Hotel, Chicago, Ill.......... May 11, 1927
Christy, J. F. Gen. Mgr., City Water & Light Plant, 411 Union St., Jonesboro, Ark.......... Jan. 12, 1925
Claflin, Charles R. Supt. Water Co., Rennselaer, N. Y.......... Sept. 30, 1919
Claiborne, Herbert A. Contracting Engineer, 204 West Franklin St., Richmond, Va.......... May 7, 1917
*Clark, A. E. Assoc. San. Engr., Department of Public Health, Tennessee Memorial Bldg., Nashville, Tenn.......... June 10, 1919
Clark, Arthur T. 11 E. Union St., Bay Shore, N. Y.......... May 16, 1919
*Clark, Charles M. Bank of Manhattan Co., Bridge Plaza, Room 402, Long Island City, N. Y.......... Apr. 4, 1924
Clark, E. W. American Water Works & Elec. Co., 114 Carman Ave., Operating Dept., Lynbrook, L. I.......... Mar. 8, 1924
*Clark, Fredk. W. G. Water Works Engr., British Municipal Council, Tientsin, China.......... June 22, 1923
Clark, H. W. Prest. H. W. Clark Co., Mattoon, Ill.......... May 29, 1895
*Clark, Harry W. Chf. Chmst., State Dpt. Hlth. Rm. 541, State House, Boston, Mass.......... May 26, 1920
*Clark, William G. Cons. Engr., 1047 Spitzer Bldg., Toledo, Ohio.......... July 8, 1908
*Clark, William H. Supt. Water Works, Avon, N. Y.......... May 31, 1916
*Clarke, Leonard. Distr. Mgr., Oregon-Wash. Water Service Co., 109 E. 10th St., Vancouver, Wash.......... Mar. 5, 1921
*Clayton, Nelson J. Supt., Pottsville Water Co., 221 Centre St., Pottsville, Pa.......... Mar. 27, 1925
Clemens, Albert. 303 Speed Building, Louisville, Ky.......... Apr. 28, 1925
Cleveland, E. A. Chf. Comnr., Greater Vancouver Water Dist., 1303 Bekins Bldg., Vancouver, B. C., Canada.......... Mar. 12, 1924

*CLEVELAND, H. BURDETT. Transportation Bldg., 225 Broadway, New York, N. Y. .... Aug. 1, 1923
*CLEVERDON, WALTER S. L. Supervisor of Property & Assoc. Prof. of Sanitary Engineering, N. Y. Univ., Wash. Square, New York, N. Y. .... Apr. 3, 1916
*CLIFTON, CHARLES ELMER. Chemist, Cannon Bldg., Troy, N. Y. .... Mar. 12, 1910
CLOWES, JOHN HENRY. Specialist in W. W. Finance, 551 Fifth Ave., New York, N. Y. .... June 15, 1927
COBURN, B. F. Superintendent Water Works, Robersonville, N. C. .... Aug. 28, 1926
COBURN, JAMES W. Treasr. Rensselaer Water Co., P. O. Box 868, Portland, Me. .... Feb. 19, 1923
COCHRAN, HORACE J. Pres., Maysville Water Co., Maysville, Ky. .... May 28, 1924
COCHRAN, J. D. Supt. Water Works, Statesville, N. C. .... Dec. 8, 1923
COFFEY, G. J. Pres., G. J. Coffey Co., Natrona, Pa. .... June 17, 1926
*COFFIN, T. DEL. Asst. Engr., Bureau Water Supply City of N. Y., Katonah, N. Y. .... Apr. 14, 1922
COLE, EDWARD S. Prest., The Pitometer Co., 50 Church St., New York, N. Y. .... June 12, 1902
COLE, JOHN A. 1346 E. 53rd St., Chicago, Ill. .... May 26, 1927
COLEMAN, JOS. L. Secy. & Supt., Citizens Water Company, P. O. Box 537, Deer Lodge, Mont. .... Mar. 13, 1925
COLES, JOHN. Supt., Water Works, West York Township, 64 Earlsdale Yard, Toronto, 10, Canada .... Mar. 16, 1927
*COLLIER, F. E. Supt., Municipal Water Works, 253 Broad St., Cookeville, Tenn. .... Apr. 13, 1926
COLLINS, A. Water Comnr., 981 Jepson St., Niagara Falls, Ont., Canada .... June 8, 1921
*COLLINS, W. D. Chemist, U. S. Geological Survey, Washington, D. C. .... Dec. 18, 1925
*CONARD, W. R. Savings Institution Bldg., Burlington, N. J. .... June 7, 1904
CONNOR, F. J. 221 No. Spring Ave., Sioux Falls, S. Dak. .... May 16, 1900
CONRATH, GEORGE A. Des Moines Water Works, Des Moines, Iowa .... Aug. 18, 1925
COOK, JOHN H. Hyd. Passaic Consol. Water Co., 158 Ellison St., Paterson, N. J. .... July 10, 1906
COOK, RODNEY E. 4237 155th St., Flushing, L. I., N. Y. .... Jan. 6, 1926
COOKE, J. R. Supt. Water Works, Franklinton, N. C. .... Sept. 10, 1925
*COOKINGHAM, L. P. Village Manager, Village Hall, Clawson, Mich. .... Feb. 18, 1927
*COONEY, EDWARD J. Mgr., Port Chester Water Works, Port Chester, N. Y. .... Feb. 8, 1928
*CORBETT, CHARLES F. Filtration Engineer, City Power Plant Dept., Edmonton, Alberta, Canada .... Jan. 26, 1928
CORCORAN, HARRY J. Chf. Engr. Iowa Ins. Serv. Bur., 431 Ins. Exchg. Bldg., Des Moines, Iowa .... Jan. 2, 1924
*COREY, RAY HOWARD. Gnl. Mgr., Coos Bay Water Co., Marshfield, Ore. .... June 19, 1920
*CORIN, MAGNUS F. Chemist, 511 Hansberry St., Germantown, Pa. .... Apr. 20, 1910
*CORINE, GEORGE A. Supt., Water & Gas Dept., Superior Water, Light & Power Co., Superior, Wis. .... Oct. 31, 1924
CORNELL, CHAS. BROWN. Mahoning Valley Sanit. Dist., 901 City Bank Bldg., Youngstown, O. .... May 31, 1928
*CORTESE, J. R. Supt., Water Works, 411 So. Second St., Livingston, Mont. .... Mar. 13, 1925

COSCULLUELA, JUAN ANTONIO. Cons. Engr., San Lazaro 232 Altos, Havana, Cuba.......... Oct. 16, 1913
*COUGHLAN, ROBERT E. Sprvsr. Wts. Sup. C. & N. W. Ry. Co., 4059 W. Monroe St., Chicago, Ill.......... Feb. 28, 1923
*COULTER, WALDO S. Cons. Engr., 114 Liberty St., New York, N. Y.......... Nov. 17, 1916
COWAN, P. H. Supt., Public Utilities, Galt, Ont., Canada.. June 9, 1919
*COWLES, M. WARREN. Hackensack Water Co., Filtration Plant, New Milford, N. J.......... Apr. 7, 1919
COWLES, ROBERT F. Engineer in Charge, Bureau of Water Development, 209 Pacific Bldg., San Diego, Cal....... Oct. 25, 1926
*COX, CHARLES R. Asst. Engineer, State Department of Health, Albany, N. Y.......... July 30, 1921
COX, GEORGE W. Supt. of City Utilities, Harlan, Iowa..... Oct. 31, 1923
COX, HOMER F. Chief Engr. Scranton Gas and W. Co., 430 Colfax Ave., Scranton, Pa.......... May 12, 1914
*CRAIG, EDWARD M., JR. Apt. 51, 144 21st St., Jackson Heights, N. Y.......... Oct. 11, 1923
CRAIG, J. O. Supt. Water Works, Salisbury, N. C.......... May 24, 1922
*CRAIG, JAMES J. City Engr. & Water Works Supt., City Bldg., Zion, Ill.......... Apr. 6, 1928
*CRAIG, ROBERT HALL. Cons. Engr., 222 No. 3rd St., Harrisburg, Pa.......... May 26, 1919
CRAMER, HUGH R. Chf. Engr. Lexington Water Co., Lexington, Ky.......... May 23, 1923
*CRAMER, W. S. Vice Pres. & Manager, Lexington Water Co., Lexington, Ky.......... May 12, 1908
*CRANCH, EUGENE T. 156 Weyman Ave., New Rochelle, N. Y. Mar. 19, 1922
*CRANE, ARTHUR M. 333 W. 25th Place, Chicago, Ill....... May 26, 1918
CRAWFORD, HOMER C. Prest. Centerville Water Co., Cooperstown, Pa.......... June 6, 1919
CRAWFORD, U. L. Engr. & Mgr., Tyrone Gas & Water Co., Tyrone, Pa.......... Mar. 27, 1925
CRICHTON, ANDREW B. Secty. and Trs., Portage Water Co., Johnstown, Pa.......... May 29, 1915
CROCKETT, HARVEY S. City Superintendent, 118 Schiller St., Elmhurst, Ill.......... Jan. 26, 1924
*CROFOOT, E. H. Supt. City Water Works, Mason City, Iowa. Oct. 5, 1923
*CROFT, H. P. Ch. Eng. State Dept. of Health, 208 Maple Ave., Trenton, N. J.......... Jan. 7, 1924
CROLL, EMIL A. 1200 Gran Blvd., Iron Mountain, Mich..... Sept. 7, 1893
*CROW, J. W. Supt. of Water & Light, Municipal Bldg., Ponca City, Okla.......... Feb. 23, 1924
*CROWLEY, CORNELIUS M. Water Registrar, St. Paul, Minn.. Oct. 18, 1918
CROZIER, RAY. Engr. and Supt., Peoria Water Works, Peoria, Ill.......... Feb. 5, 1915
*CRUGER, C. B. 2248 Nowland Ave., Indianapolis, Ind...... Nov. 15, 1924
CRUM, EMORY CLAY. City Engineer, P. O. Box No. 354, Frederick, Md.......... Feb. 13, 1924
*CUDDEBACK, ALLAN W. V. P. and Treas. Passaic Consol. Water Co., 158 Ellison St., Paterson, N. J.......... June 7, 1904
CULYER, THURSTON C. 114 Goodrich St., Astoria, L. I., N. Y.......... June 26, 1910
CUMMINGS, CHARLES R. Water Supt., 11336 Court St., Lynwood, Calif.......... June 11, 1928
*CUNDIFF, STUART A. Supt. City Water Dept., Newport Beach, Calif.......... May 24, 1927
CUNLIFFE, RUSSELL W. Health Dept., City Hall, Milwaukee, Wis.......... Dec. 13, 1926

CUNNINGHAM, F. G. c/o Fuller & McClintock, 170 Broadway, New York, N. Y. .... Apr. 30, 1923
CURD, P. B. Commissioner of Public Utilities, City Water Department, Wichita Falls, Texas .... May 12, 1925
CURRAN, JAMES E. Supt., Water Bureau, 79 Linden St., Yonkers, N. Y. .... Mar. 30, 1926
CURRIE, C. H. Cons. Engr., Webster City, Ia. .... Apr. 20, 1920
CURTIS, FRANCIS J. Merrimac Chemical Co., 148 State St., Boston, Mass. .... Apr. 20, 1928
*CURTIS, J. EUGENE. Filtn. Plant, Washington, D. C. .... May 3, 1923
CUTLER, LEON G. 229 Satterthwaite Ave., Nutley, N. J. .... Jan. 31, 1925
CUTTS, FRANCIS T. 306 Merchants-Laclede Bldg., St. Louis, Mo. .... June 15, 1914

*DALLYN, F. A., C.E. 71 King St., W., Toronto, Ont., Can. Feb. 2, 1916
*DAMEROW, HARRY W. Supt., Light & Water Department, Vero Beach, Fla. .... Dec. 22, 1926
DANIEL, FRANK R. Chief Engr., Wisconsin Inspec. Bureau, 490 Broadway, Milwaukee, Wis. .... Aug. 18, 1924
*DANIELS, FRANCIS E. Eng. Div. State Dept. of Health, 2115 No. Second St., Harrisburg, Pa. .... Sept. 2, 1916
*DAPPERT, JAMES W., C.E. Lock Box 141, Taylorville, Ill. Oct. 23, 1914
*DARBY, W. ALLEN. San. Engr., The Dorr Company, 247 Park Ave., New York, N. Y. .... June 6, 1927
*DARLING, ERNEST HOWARD, M.E. Consulting Engineer, 21 Stanley Ave., Hamilton, Ont., Canada .... Dec. 29, 1925
*DARROW, WARREN E. 314 Masonic Temple, Columbus, Ga. Dec. 22, 1926
DAVIDSON, GEORGE M. Ind. Engr., C. & N. W. Ry. Co., 211 N. East Ave., Oak Park, Ill. .... Mar. 11, 1915
DAVIES, HUGH. Master Mechanic, Hackensack Water Company, 624 Park Ave., Weehawken, N. J. .... Mar. 13, 1925
DAVIS, A. A. Local Mgr., California Water Service Co., 606 Bird St., Oroville, Calif. .... May 31, 1927
*DAVIS, ARTHUR P. 505 Santa Ray Ave., Oakland, Calif. .... Feb. 9, 1924
DAVIS, C. A. Superintendent Water Works, Box 748, Homestead, Fla. .... Dec. 22, 1926
DAVIS, CARLETON E. Manager, Phila. Suburban Water Co., 762 Lancaster Ave., Bryn Mawr, Pa. .... Apr. 28, 1912
*DAVIS, FRANK J. Supt., Ansonia Water Co., 354 Main Street, Ansonia, Conn. .... May 15, 1916
*DAVIS, H. F. Representing Wallace & Tiernan Co., c/o Charlotte Water Wks., Charlotte, N. C. .... Dec. 8, 1923
DAVIS, P. D. Asst. Engr., c/o Wm. M. Piatt, Durham, N. C. Jan. 12, 1922
DAVIS, W. L. Supt., Water Dept., P. O. Box 266, Portsmouth, Va. .... July 8, 1922
DAW, LAWRENCE. Chf. Engr., Underwriters Assn. of N. Y., 700 Gurney Building, Syracuse, N. Y. .... May 9, 1916
*DAY, LEONARD A. Water Commissioner, 312 City Hall, St. Louis, Mo. .... Apr. 24, 1917
DEAN, JOHN M. Water Commissioner, First Natl. Bank Bldg., Memphis, Tenn. .... June 6, 1927
DEAN, SILAS S. Mechanical Engineer, Aurora, Ill. .... June 6, 1927
*DEBERARD, W. W. Engineering News-Record, 7 So. Dearborn St., Chicago, Ill. .... June 3, 1912
*DE BRITO, F. SATURNINO R. Consulting Engineer, Caixa Postal 1631, Rio de Janeiro, Brazil .... Jan. 25, 1926
*DECKER, A. CLINTON. Sanitary Engr., Tenn. Coal, Iron & Railroad Co., Birmingham, Ala. .... June 2, 1914

*DECKER, ARTHUR J. Consulting Civil Engr., 2014 Geddes Ave., Ann Arbor, Mich.	May 23, 1923
DECOSTA, JOSEPH D. 41 Lenox Road, Berkeley, Calif.	Sept. 17, 1923
DE HORATIIS, MANFREDI. R. Instituto Forestale, Firenze, Italy	Apr. 30, 1926
DE JOSEZ, JULES. Civil Engineer, 655 Powell St., San Francisco, Calif.	Jan. 6, 1928
DELANEY, J. T. Supt. City Water Works, Los Banos, Calif.	Oct. 14, 1924
*DELAPORTE, A. V. Chemist in Charge, Experimental Sta., Clifford St., Dept. of Health of Ontario, Toronto, Ont., Canada	Mar. 27, 1925
DE LA VEGA, RAMIRO, Mgr. Municipal Water Works, Apartado No. 58, Cartagena, Colombia, S. A.	Feb. 28, 1928
*DELEUW. CHARLES E. Kelker, DeLeuw & Co., Engrs., 111 W. Washington St., Chicago, Ill.	Nov. 30, 1923
*DEMARTINI, FRANK EDWARD, Sanitary Engineer, 637 Greenwich St., San Francisco, Calif.	Sept. 13, 1927
DEMOYA, P. PAUL. Mgr., Consumers Water Co., Stuart, Fla.	Dec. 22, 1926
*DENMAN, CHARLES SING. Genl. Mgr. Des Moines Water Co., Des Moines, Iowa	Dec. 10, 1915
*DENNETT, ROBERT C. Hyd. Engr., c/o Natl. Board Fire Underwriters, 85 John St., New York, N. Y.	May 15, 1914
*DERBY, R. L. 937 So. Curson Ave., Los Angeles, Calif.	May 29, 1926
*DEVENDORF, EARL. Asst. San. Engr. St. Dept. of Hlth., 1239 Albany St., Schenectady, N. Y.	May 22, 1919
DEVILBISS, H. ROLAND. Dept. Engr., Washington Suburban Sanitary Dist., Hyattsville, Md.	Apr. 10, 1922
DEWEY, CHESTER R. Vice Pres., Consolidated Water Co. of Utica, First National Bank Building, Utica, N. Y.	Jan. 19, 1926
DI DOMENICO, ANTHONY F. 727 Aisquith St., Baltimore, Md.	Mar. 9, 1927
DIEHL, GEORGE C. Cons. Engr., 577 Ellicott Square, Buffalo, N. Y.	May 15, 1923
DIENERT, M. 6 Rue de Seine, Paris VI, France	Feb. 28, 1925
*DIETRICH, FRED. W. Dist. Mgr., Oregon-Wash. Water Service Co., Hoquiam, Wash.	Jan. 26, 1928
DIGGS, FRANKLIN, JR. San. Engr., Linthicum Heights, Md.	Sept. 11, 1923
*DIGGS, JOHN C. San. Engr., Department of Conservation, 126 State Capitol, Indianapolis, Ind.	Sept. 9, 1919
*DIGNAN, B. T. Chem. and Bact., City Water Works, Niagara Falls, N. Y.	Apr. 10, 1919
*DILL, H. A. Supt., Water Works, Richmond, Ind.	May 16, 1900
DILLER, J. W. Superintendent, Water Works, Wilber, Nebr.	July 31, 1924
*DILLON, S. E. Local Mgr., California Water Service Co., Box 1148, Bakersfield, Calif.	May 31, 1927
DISH, EDWARD. Gamon Meter Co., 922 Milton Ave., South Bend, Ind.	Feb. 7, 1925
*DISHNER, P. J., Supt. Water Works, High Point, N. C.	Nov. 19, 1927
*DITTOE, W. H. Chief Engineer, Mahoning Valley Sanitary District, Youngstown, Ohio	May 28, 1914
DIVEN, JOHN M., JR. The Leadite Company, Inc., 118—19th St., Jackson Heights, L. I., N. Y.	June 17, 1913
*DIXON, FREDERIC JOHN. Chf. Engr. Staffordshire Wtr. Wks., 264 Paradise St., Birmingham, England	Aug. 8, 1919
*DIXON, G. GALE. Office Engineer, The Mahoning Valley Sanitary District, 901 City Bank Bldg., Youngstown, Ohio	June 21, 1920
DIXON, JAS. I. Superintendent Water Dept., 401 Benton St., Santa Clara, Calif.	May 14, 1926

*Dobbin, R. L. Supt. Water Works, 223 Aylmer St., Peterborough, Ont., Can. .... Feb. 28, 1923
*Dodd, Rennie I. Federal Water Service Corp., 27 William St., New York, N. Y. .... Apr. 10, 1922
Dodge, Fred L. Asst. Mgr., Belvedere Water Corp., 4163 Whittier Blvd., Los Angeles, Calif. .... July 22, 1926
*Dodge, Walter, M. D. Bact., Dept. of Health of Orange, 36 Cleveland St., Orange, N. J. .... Feb. 24, 1928
*Domogalla, Dr. Bernhard. Chemist, University Club, 803 State St., Madison, Wisc. .... Feb. 17, 1926
*Donaldson, Wellington. c/o Messrs. Fuller & McClintock, 170 Broadway, New York, N. Y. .... Apr. 29, 1910
Dones, J. W. Asst. Supt. & Engineer, City Water Department, Tulsa, Okla. .... June 6, 1927
*Donnelly, R. V. Pres., The Paradon Mfg. Co., 573 Elm St., Arlington, N. J. .... Apr. 7, 1917
Donohue, Jerry. Prest., Donohue Engineering Co., Sheboygan, Wis. .... June 20, 1922
*Dorisy, C. Edmond. Cons. Engr., Securities Bldg., Seattle, Wash. .... Nov. 23, 1917
Dorrance, Frank Young. Divn. Engr., Montreal Water Bd., 341 Brock Ave., North, Montreal West, P. Q., Can., ... July 14, 1920
*Dorsey, Stanton L. Sanitary Engineer, Room 790, Arlington Bldg., Washington, D. C. .... May 28, 1924
Dorsey, Victor A. Consulting Engineer, 1560 First Natl. Bank Bldg., Chicago, Ill. .... Aug. 22, 1928
Doten, Capt. Leonard S. In Charge of Construction Work, Wright Field, Dayton, Ohio .... Aug. 19, 1914
Dougherty, Ben R. Supt., Richmond Water & Light Co., Richmond, Ky. .... Apr. 16, 1924
Dougherty, D. J. Mgr. & Supt., P. O. Box 418, Talladega, Ala. .... May 12, 1925
*Douglass, Robert M., C. E. 912 Columbia Bank Bldg., Pittsburgh, Penn. .... May 12, 1923
Dow, Alex. 2000 Second Ave., Detroit, Mich. .... Aug. 4, 1919
*Dowd, John E. 162 85th St., Brooklyn, N. Y. .... Mar. 4, 1922
*Dowling, F. F. Chief Engineer, British Columbia Fire Undwtrs., 1021 Rogers Bldg., Vancouver, B. C., Canada. .... May 31, 1924
*Downer, T. B. Chf. Engr. & Supt., Alhambra Water Dept., 210 South Fifth Street, Alhambra, Calif. .... Apr. 9, 1925
*Downes, John R. Green Brook Park, Bound Brook, N. J. .... July 10, 1906
*Drake, Chester F. Div. Supt., Pittsburgh Filtration Plant, Aspinwall, Pa. .... Apr. 27, 1910
Drake, Edward, C. E. New Bedford, Mass. .... Jan. 29, 1921
*Drake, William O. City Engr., Supt. Public Works, City Hall, Corning, N. Y. .... Apr. 30, 1917
Drane, Brent S. Consulting Engineer, 19 W. 4th St., Charlotte, N. C. .... June 28, 1924
Draper, Oscar C. Water Commissioner, N. W. Cor. 7th & Jackson Sts., Wilmington, Dela. .... Jan. 27, 1926
*Druar, John F. Cons. Engr., 500-504 Globe Bldg., St. Paul, Minn. .... Nov. 18, 1919
*Dryden, Francis H. City Engineer, Salisbury, Md. .... May 13, 1924
Duane, Louis V. Superintendent of Water Works, City Utilities, Sanford, Fla. .... Aug. 19 1926
Duffy, James M. Village Engineer, Mamaroneck, N. Y. .... June 6, 1922
Dugger, Eugene F. Gen. Mgr., Newport News Waterworks Comn., Newport News, Va. .... May 17, 1924

DuMoulin, W. L. Gnl. Supt., New Cornelia Copper Co., Ajo, Arizona...... June 18, 1910
*Dunham, H. F., C.E. 32 West 40th St., New York, N. Y.... Apr. 16, 1884
*Dunham, Henry G. 920 Henry Street, Detroit, Mich...... June 16, 1925
*Dunn, Wm. Carey. Supt. Mt. Hope Filter Plant, Box 541, Cristobal, C. Z...... Nov. 12, 1919
*Dunwoody, J. S. Supt., Water Department, Erie, Pa...... June 5, 1913
*Durbin, W. H., C.E. Asst. Mgr. T. H. Water Works Co., 634 Cherry St., Terre Haute, Ind...... May 23, 1923
Durland, Smith N. Cashier, Long Island Water Corp., 15 John St., Far Rockaway, N. Y...... Jan. 29, 1914
Dwyer, Cornelius. 18 Chuctanunda St., Amsterdam, N. Y.. Apr. 11, 1914
Dwyer, John D. Chairman, Water & Sewer Board, 110 So. Border Road, Medford, Mass...... May 24, 1922
Dyhrkopp, F. G. Mgr., Dyhrkopp Engineering Co., 222½ South Illinois Ave., Carbondale, Ill...... Nov. 18, 1925

Eagan, Owen J. Water Commissioner, Somerset, Mass...... June 6, 1927
*Earl, Ralph. Hyd. Engr., Sewerage and Water Board, Water Purification Dept., New Orleans, La...... June 6, 1916
*Easby, William, Jr. Civil & Sanitary Engr., 1201 Chestnut St., Philadelphia, Pa...... Mar. 12, 1924
Easterday, E. E. Assistant Division Engineer, Supply & Purifying Sec., Water Div., 4539 Arco Ave., St. Louis, Mo...... May 29, 1926
*Eastwood, Charles H. San. Engr., Bureau of Engineering, Fla. State Board of Health, Jacksonville, Fla...... May 28, 1926
*Eastwood, John Thompson. Prin. Asst. Engr., Sewer & Water Bd., City Hall Annex, New Orleans, La...... May 24, 1909
Ebeler, Charles J. Supt. of Distribution, Water Dept., 4600 McRee Ave., St. Louis, Mo...... May 17, 1927
*Eddy, Harrison P. Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass...... May 20, 1925
Eddy, Justus B. Engineer, Water Pipe Extension, 404 City Hall, Chicago, Ill...... June 21, 1926
Edwards, William R. Supt. Passaic Consol. Water Co., 158 Ellison St., Paterson, N. J...... Apr. 2, 1914
*Eggert, E. G. Prin. Asst. State Sanitary Engr., Texas State Dept. of Health, Austin, Tex...... Oct. 18, 1927
Eginton, James T. Supt. Cortland Water Dept., 23 Court Street, Cortland, N. Y...... Apr. 10, 1926
Ehle, Chester G. Chf. Dftsmn. & Distbn. Engr. Wtr. Bureau, 211 City Hall, Portland, Ore...... Mar. 21, 1923
*Ehlers, V. M. Chief Sanitary Engr., Texas State Dept. of Health, Austin, Tex...... Oct. 18, 1927
Ehrhart, C. L. City Manager, Clarinda, Iowa...... Apr. 30, 1919
*Elder, Albert L. Chemist, State Water Survey, 128 Morgan St., Oberlin, Ohio...... Sept. 18, 1928
Eldridge, H. D. Treas., Princeton Water Co., Princeton, N. J...... Apr. 14, 1916
Elliott, Earl C. Vice Pres., Federal Water Service Corp., 27 William St., New York, N. Y...... July 31, 1928
Elliott, G. A. Chf. Engr., Spring Valley Water Co., 425 Mason St., San Francisco, Calif...... May 15, 1918
Ellis, George R. Canandaigua, N. Y...... July 18, 1907
*Ellis, Herbert C. 8100 W. Warren Ave., Detroit, Mich...... July 27, 1926
*Ellis, Luke. Serv. Engr., Pub. Serv. Comm. of Md., 1722 Munsey Bldg., Baltimore, Md...... Sept. 23, 1924

ELLIS, N. RANDALL. Valtn. Engr. City Atty. Office, 453 City Hall, San Francisco, Calif. June 9, 1920
*ELLMS, JOSEPH W. 1310 West 112th Street, Cleveland, Ohio. Oct. 21, 1919
ELLSWORTH, FRED D. Local Mgr., Petaluma Power & Water Co., 114 Main St., Petaluma, Calif. Oct. 10, 1927
ELLSWORTH, HARRY. Supt. Water and Light Dept., Meadville, Pa. July 18, 1907
ELLWOOD, OLIVER. Sect., Public Utilities Comn., London, Ont. Feb. 8, 1928
*ELROD, HENRY E. Mills-Fraser Bldg., Room 209, Santa Monica, Calif. Feb. 2, 1916
*ELY, HOWARD M. Superintendent Water Co., Danville, Ill. June 8, 1909
*ELY, JOHN S. Division Engineer, Div. of Water, Room B3, City Hall, Newark, N. J. Mar. 20, 1922
*EMERSON, C. A., JR. 804 Pennsylvania Bldg., 15th & Chestnut Sts., Philadelphia, Pa. May 12, 1908
*EMERSON, FRANK. Engr. & Supt. of Public Wks., Melrose, Mass. Nov. 12, 1919
EMPARAN, R. R. Manager, Sonoma Water & Irrigation Co., Sonoma, Calif. June 15, 1926
ENANDER, E. H. Engr., Distr. Public Service Co. of Northern Ill., 75 W. Adams St., Chicago, Ill. June 27, 1922
END, WILLIAM F. Civil Engineer, 360 Third St., Troy, N. Y. Jan. 19, 1926
*ENGEL, P. N. 333 W. 25th Place, Chicago, Ill. June 12, 1919
*ENGER, M. L. Prof. Mechanics and Hydraulics, Univ. of Ill., Urbana, Ill. Mar. 11, 1915
ENGH, HARRY M. Acting Mgr., Mutual Telephone Co., Mutual Telephone Bldg., Erie, Pa. Mar. 25, 1916
*ENGLAND, R. G., C.E. Fargo Engineering Co., 147 So. Mechanic St., Jackson, Mich. Sept. 2, 1914
*ENGLE, JAMES W. Big Bethel Water Development, R. F. D. No. 2, Box 110, Hampton, Va. Sept. 4, 1923
ENNIS, HARRY W. City Engineer, City Hall, Bowling Green, Ky. Oct. 20, 1926
*ENSLOW, L. H. c/o The Chlorine Institute, Inc., 30 East 42nd St., New York, N. Y. Aug. 16, 1918
ERICKSON, CHARLES A. Supt. of Water Works, 622 East Main St., Sparta, Wis. July 30, 1925
ERICKSON, D. L. City Engineer, Lincoln, Nebr. June 30, 1924
*ERICKSON, WENDELL J. Asst. Sanitarian, State Dept. of Health, 1552 Nott St., Schenectady, N. Y. Jan. 19, 1924
ERVAST, ANDREW. Mgr., Coronado Water Co., 440 Union Bldg., San Diego, Calif. Oct. 11, 1923
ESTY, ROGER W. Supt., 17 Hobart St., Danvers, Mass. Mar. 1, 1924
EVANS, CHARLES. Supt. of Constr., 540 Haller St., Lima, O. May 26, 1923
*EVANS, EDMUND BOYCE. Asst. Bacteriologist, Water Works, 1215 Elgin Pl., Mt. Adams, Cincinnati, Ohio. Jan. 27, 1927
*EVANS, G. TAYLOR. Supt., Mahoning Valley Water Co., Struthers, Ohio. Apr. 6, 1928
*EVERETT, CHESTER M. Hazen and Whipple, 25 W. 43rd St., New York, N. Y. May 10, 1915
EVERETT, JASPER W. Supt., Penobscot Co. Wtr. Co., Orono, Me. May 5, 1922
EVERETTE, WILLIS EUGENES. P. O. Box 188, San Rafael, Calif. Dec. 29, 1913
EWING, JAMES. Hunter Dist. Water Sup. and Sew. Bd., Newcastle, N. S. W., Australia. Nov. 5, 1913

*EWRY, RAY C. Municipal Bldg., Rm. 2200, New York, N. Y. .... Apr. 4, 1924
EYMER, HERMAN H. City Engineer, Saginaw, Mich. .... June 4, 1912

*FAGER, E. P. Chst. & Bct. Dearborn Chem. Co., 1029 W. 35th St., Chicago, Ill. .... Aug. 5, 1920
*FAIR, AL. Commissioner, Water Dept., Casper, Wyo. .... Jan. 14, 1927
*FAIR, GORDON MASKEW. Assoc. Prof. of San. Engineering, Harvard University, 112 Pierce Hall, Cambridge, Mass. .... Jan. 26, 1925
*FAITOUTE, FREDERIC B. Civil Engr. & Water Works Supt., 138 Sayre Street, Elizabeth, N. J. .... Aug. 11, 1927
*FALES, ALMON L. Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass. .... Feb. 26, 1921
FARQUHARSON, ALEX. L. Mgr. Brockville Public Utilities, Victoria Hall, Brockville, Ont., Can. .... Mar. 8, 1924
*FARRELL, JAMES W. D. Supt. Water Works, 3035 Rae St., Regina, Sask., Can. .... Feb. 23, 1920
FARRELL, L. L. Supt. East Bay Water Co., 512 Sixteenth St., Oakland, Calif. .... Sept. 21, 1922
FARRELL, THOMAS S. 1054 Kenneth Dr., Rocky River Br., Cleveland, Ohio .... June 7, 1921
FASOLI, P. Supt. Springbrook Water Co., Hudson Falls, N. Y. .... July 12, 1922
FEENEY, A. J. Asst. Engr. & Supt. Water Dept., Wilmington, Del. .... Apr. 30, 1919
FEETER, SILAS S. City Engr. & Supt. Water Works, Little Falls, N. Y. .... Oct. 22, 1921
FEIST, MARTIN. Supt. Mch. Eqpt. St. P. Wtr. Wks., Dayton's Bluff Stn., B. 4, St. Paul, Minn. .... May 13, 1919
FELIX, GEORGE H. 138 N. Ninth St., Reading, Pa. .... Sept. 7, 1893
*FENKELL, GEORGE H. Supt. and Gnl. Mgr. Bd. Wtr. Comnrs., Jefferson and Randolph Sts., Detroit, Mich. .... June 21, 1920
FENN, N. FREDERICK, JR. 50 No. Clinton Ave., Bay Shore, N. Y. .... Nov. 5, 1927
*FERGUSON, EMERY E. North American Water Works Corp., 11 Broadway, New York, N. Y. .... Apr. 10, 1922
*FERGUSON, G. H., B.A.Sc. Chief Engr., Dept. of Health, Elgin Building, Ottawa, Canada .... Mar. 19, 1925
*FERGUSON, HARRY FOSTER. Chf. Eng., State Dept. of Hlth., Springfield, Ill. .... Nov. 9, 1914
FERGUSON, JOHN B., C.E. Hagerstown, Md. .... Sept. 30, 1919
FERRIS, T. E. Chrmn. Wtr. Comnrs., Niagara Falls, Ont., Can. Feb. 10, 1921
*FEWELL, J. H. Superintendent, Water Dept., Jackson Miss. .... June 17, 1926
*FIELD, FREDERICK E. Engr. Water Bd., 135 Ballantyne Ave., Montreal, West, P. Q., Can. .... June 21, 1920
*FIELD, WILLIAM T. Consulting Engineer, Flower Bldg., Watertown, N. Y. .... Apr. 27, 1910
*FIELDS, F. V. Supt., Water & Light Dept., Mooresville, N. C. Apr. 23, 1924
*FILBY, E. L. Chf. San. Engr., State Board of Health, Jacksonville, Fla. .... Feb. 7, 1922
FINCH, J. D. Zebulon, N. C. .... Aug. 28, 1926
*FINCH, RONALD M. Wallace & Tiernan Co., Inc., 240 So. 4th St., Rm. F, Minneapolis, Minn. .... May 26, 1925
*FINK, G. J. Director of Research, Chicago Chemical Co., 6216 W. 66th Place, Chicago, Ill. .... Apr. 8, 1924
FINKLE, F. C. Consulting Hydraulic Engineer, 717–721 American Bank Building, Los Angeles, Calif. .... June 24, 1912

*Finneran, Geo. H. Supt. Water Service, 710 Albany Ave., Boston, Mass. Feb. 18, 1921
*Fisher, E. A. Consulting Engineer, Rochester, N. Y. June 4, 1912
Fisher, L. A. P. O. Box 198, Concord, N. C. Jan. 27, 1914
*Fishtein, Max. 4534 Osage Ave., Philadelphia, Pa. Dec. 29, 1927
*Fitzgerald, Howard. Chf. Engr., Buffalo Water Works, Col. Ward Pumping Station, Porter Ave., Buffalo, N. Y. Apr. 20, 1923
Flaa, Ingwald E. Asst. Engr., Spring Valley Water Co., 425 Mason St., San Francisco, Calif. May 14, 1915
Flack, Horace E. Executive, Dept. Legislative Reference City Hall, Baltimore, Md. June 16, 1919
*Flad, Edward. 1312 Chemical Bldg., St. Louis, Mo. July 23, 1919
Flannery, William. M. E., Dept., W. S. G. & E., N. Y., 313 Park Place, Brooklyn, N. Y. May 9, 1921
*Fleming, John D. Asst. Chem. Engr., Water Divn., 34 E. Grand Ave., St. Louis, Mo. May 17, 1927
Fleming, Virgil R. 204 Lab. App. Mech., Urbana, Ill. Apr. 14, 1915
*Flentje, Martin E. Community Water Service Co., 702–05 Yoffee Bldg., Harrisburg, Pa. Mar. 27, 1926
*Fletcher, Alfred H. Asst. San. Engr., State Board of Health, c/o Health Unit, Monroe, La. Dec. 20, 1927
*Folwell, A. Prescott. 7 Erwin Park, Montclair, N. J. July 10, 1906
Foote, A. J. Hillside Arcade, Larchmont, N. Y. Jan. 6, 1927
Foote, Francis C. Sr. Asst. Engr., Morris Knowles, Inc., 507 Westinghouse Bldg., Pittsburgh, Pa. May 28, 1924
*Foote, Herbert B. Director, Div. Water & Sewage, State Board of Health, Helena, Mont. Aug. 1, 1923
Ford, J. W. Engr. San Jose Water Works, 374 W. Santa Clara St., San Jose, Calif. Jan. 26, 1924
Foreman, Charles S. Gen. Supt., Smith Bros., Inc., 600 Walsix Building, Kansas City, Mo. June 21, 1920
*Foreman, Merle S. Biologist, Calif. State Board of Health, 2208 Derby St., Berkeley, Calif. Jan. 17, 1928
*Forsberg, Ole. Chemist, Oliver Iron Mining Co., Hibbing, Minn. Mar. 14, 1921
*Foster, Charles. Cons. Engr., 512 Selwood Bldg., Duluth, Minn. June 9, 1919
*Foulk, C. W. Professor of Analytical Chemistry, Ohio State University, Columbus, Ohio. June 17, 1926
*Foulks, John A. Cons. Engr., 20 Beaver St., Newark, N. J. Dec. 23, 1921
*Foutz, Charles C. Supt., Laporte Water Works, 212 Holcomb St., La Porte, Ind. Feb. 23, 1926
*Fowler, Arthur G. Supt. Water Works, R. F. D. #3, Cumberland, Md. Apr. 27, 1910
*Fowler, Edward A. Asst. Engr., 207 Sewerage & Water Board Bldg., New Orleans, La. Apr. 27, 1910
*Fox, Charles L. Asst. Supt., Pennsylvania Water Co., 712 South Avenue, Wilkinsburg, Pa. June 4, 1912
*Fox, Paul S. San. Engr. Bur. of Pub. Health, P. O. Box 750, Santa Fe, N. Mex. Oct. 31, 1924
Franchi, Emilio. Ing., Franchi Gregorini Company, S. Eustacchio, 4, Brescia, 25, Italy. June 6, 1927
*Fraser, Sam D. Superintendent Water Works, Carlsbad, Calif. May 20, 1926
*Freeburn, H. M. District Engineer, Penna. Dept. of Health, 508 B Midvale Avenue, Germantown, Phila., Pa. May 5, 1922
Freer, W. D. American Water Works & Elec. Co., 50 Broad St., New York, N. Y. Mar. 8, 1924

*FRENCH, D. W. 159 Lydecker St., Englewood, N. J.	May 29, 1895
*FRENCH, DUDLEY K. Chemist, Straus Bldg., Room 1912, 310 S. Michigan Ave., Chicago, Ill.	May 25, 1919
FRENCH, E. V., M.E. 185 Franklin St., Boston, Mass.	July 10, 1906
*FRETTER, A. H. Supt., Water Works, 603 S. Broadway, Medina, Ohio	Feb. 7, 1922
FRICKER, EMILE. Asst. to Mgr., Hackensack Water Company, 624 Park Ave., Weehawken, N. J.	Mar. 13, 1925
*FRIEL, FRANCIS S. Civil & Sanitary Engineer, Albright & Mebus, 112 S. Easton Road, Glenside, Pa.	Mar. 22, 1926
FRIEND, R. O. 658 E. 81st St., Chicago, Ill.	Mar. 10, 1928
*FRITZ, WILLIAM G. Contractor, West Orange, N. J.	May 28, 1924
*FUERTES, JAMES H. Consulting Engineer, Woolworth Bldg., Rm., 850, 233 Broadway, New York, N. Y.	July 10, 1906
*FULKMAN, JOHN A. 1700 Engineering Bldg., Wacker Dr. & Wells St., Chicago, Ill.	July 31, 1928
*FULLER, GEORGE W. Cons. Engr., 170 Broadway, New York, N. Y.	June 15, 1898
*FULLER, W. A. Cons. Engr., 1917 Railway Exc. Building, St. Louis, Mo.	Oct. 14, 1914
FULLER, WESTON E., C.E. Swarthmore College, Swarthmore, Pa.	May 27, 1922
*FULLERTON, HOWARD R. Director, Div. of San. Eng., Tennessee Memorial Bldg., Nashville, Tenn.	Jan. 9, 1923
*FURMAN, ROBERT W. Chf. Chemist, Water Purification Works, 1443 Kenyon Drive, Toledo, Ohio	May 25, 1922
GABY, FREDERICK A. Chf. Engr., Hydro-Electric Power Com. of Ont., 190 University Ave., Toronto, Ont., Canada	Feb. 8, 1916
*GACHE, EULOGIO M. Chemist & Bacteriologist, Compania Aguas Corrientes, Rosario de Santa Fe, Argentine	Mar. 27, 1925
GAFFNEY, C. J. Manager Meter Repairs, 299 Myrtle Ave., Brooklyn, N. Y.	June 17, 1926
*GAGE, STEPHEN DEM. 310 State House, Providence, R. I.	Apr. 27, 1925
GAILLARD, G. Y. Pres., New Haven Water Co., 100 Crown St., New Haven, Conn.	May 27, 1924
*GALLAGHER, H. A. Mgr. Water Co., Independence, Mo.	June 8, 1909
*GALLAHER, WILLIAM U. Asst. San. Engr., State Board of Health, Capitol Bldg., Madison, Wis.	Mar. 13, 1925
*GANNETT, FARLEY. President, Gannett, Seelye & Fleming, Engrs., 204 Locust St., Harrisburg, Pa.	Nov. 29, 1919
*GARMAN, H. O. Consulting Engineer, 2062 N. Meridian St., Indianapolis, Ind.	May 30, 1916
*GASCOIGNE, GEORGE B. Consulting Sanitary Engr., 648 Leader-News Bldg., Cleveland, O.	June 16, 1920
GATES, H. V. Prest., Hillsboro Power & Invest. Co., Hillsboro, Oregon	June 7, 1904
GAUL, J. V. Local Manager, Port Costa Station, California Water Service Co., Box 867, Martinez, Calif.	May 11, 1927
*GAUNT, PERCY. Chief Sanitation Chemist, c/o Shanghai Municipal Council, Shanghai, China.	Sept. 12, 1922
*GAUSMANN, R. W. c/o Ulen & Company, No. 8 Caragheorghi St., Athens, Greece	Mar. 12, 1924
*GAVETT, WESTON. Analyst, 312 W. 5th St., Plainfield, N. J.	Nov. 10, 1914
*GAYTON, L. D. City Engineer, 402 City Hall, Chicago, Ill.	Oct. 9, 1924
*GEAR, PATRICK. Supt. Water Dept., Holyoke, Mass.	June 24, 1913
GEEHAN, EDWARD A. American Water Works & Elec. Co., 50 Broad St., New York, N. Y.	Feb. 6, 1924

*Gelston, W. R. Supt. Water Works Commission, Quincy, Ill. .... May 7, 1907
Gensheimer, George C. Secty. Comrs. of Water Works, Erie, Pa. .... June 22, 1919
*Georgia, Frederick Raymond. Rollins College, Winter Park, Fla. .... May 16, 1919
Gerardy, Maurice H. 176 E. Jefferson Ave., Detroit, Mich. ... Mar. 16, 1922
*Gerhart, Robert W. Box R., Beverly Hills, Calif. .... Dec. 13, 1926
*Gerin, Maurice, M.S. Sales Engineer, Canadian Fairbanks-Morse Co., Ltd., 84 Saint Antonie St., Montreal, Que., Canada .... Feb. 10, 1926
*Gerstein, H. H. 8140 Drexel Ave., Chicago, Ill. .... Dec. 24, 1925
Gertsen, Gustav. Supt. Municipal Water Works, St. Helena, Napa County, Calif. .... May 25, 1926
*Gettrust, J. S. Supt. Akron Filt. Plant., Kent, O. .... June 8, 1921
*Geupel, L. A. c/o Ulen & Company, Eleja Ujadowskie, 37 Warsaw, Poland .... Nov. 28, 1922
Giacomazzi, P. A. 335 Pleasant St., Santa Paula, Calif. ...... Nov. 8, 1923
Gibbons, Mortimer M. Box 162, Rahway, N. J. .... Nov. 9, 1922
*Gibbs, Carl C. Supt. Glencoe Water Plant, 611 Rosemary Rd., Lake Forest, Ill. .... July 19, 1928
*Gibson, James E. Manager & Engr., Water Dept., 14 George St., Charleston, S. C. .... May 1, 1922
*Gideon, Abraham, C. E. Mgr. Metrop. Wtr. Dist., Manila, P. I. .... June 8, 1909
Gidley, Henry T. Supt. Fairhaven Water Co., Fairhaven, Mass. .... May 23, 1923
Gierlich, Henry S. City Engineer, City Hall, Monrovia, Calif. .... Dec. 21, 1925
Giesey, Jesse K. Shrewsbury, Pa. .... Sept. 30, 1919
*Gilcreas, F. Wellington. 66 Elmore St., Newton Centre, Mass. .... Apr. 4, 1924
*Gilcrist, Charles B. Supt. Water Works, Newburgh, N. Y. May 25, 1922
*Gilkison, George F., M.D. Chf. Chst. Water Dept., 5256 Brookwood Road, Kansas City, Mo. .... Apr. 24, 1920
*Gill, C. S., Supt., Carbondale Municipal Water Works, 206 W. Main St., Carbondale, Ill. .... Mar. 13, 1928
*Gillespie, C. G. Director, State Bd. Hlth., Bur. San. Engr., Box 2085, Route 3, Broadway Ter., Oakland, Calif. ...... June 10, 1911
*Gillig, John T. Engineer, 910 Fayette Bank Bldg., Lexington, Ky. .... July 28, 1924
*Ginter, Roy L. Tulsa Laboratories, Inc., 312 Richards Bldg., Tulsa, Okla. .... Sept. 7, 1926
Gitchell, H. M. Supt. Water Works, Binghamton, N. Y. ... May 7, 1924
*Glace, Ivan M. Dist. Engr., Penna. Dept. of Health, 22 So. 22nd St., Harrisburg, Pa. .... Nov. 30, 1921
Gladding, R. D. P. O. Box 217, Wilson, N. C. .... May 29, 1920
Glannan, Peter Hugh. Supt. Commonwealth Wtr. Co., W. O. Dvn., 22 Northfield Rd., West Orange, N. J. ..... June 8, 1921
Glynne, Harry N. 1676 Whitney Ave., New Haven, Conn. . Aug. 12, 1922
Goble, W. F. 7 South First St., Alhambra, Calif. .... June 17, 1926
*Godfroy, F. G. Supt. Water & Light Plant, New Bern, N. C. May 17, 1923
*Goldsmith, Clarence. Natl. Bd. Fire Underwriters, 222 W. Adams St., Rooms 929-65, Chicago, Ill. .... Dec. 27, 1915
*Goldstein, Maurice. Asst. C. E., Water Dept., 212 N. Collington Ave., Baltimore, Md. .... June 9, 1922
*Goler, George W., M.D. Health Officer, Health Bureau, Chestnut St., Rochester, N. Y .... Jan. 12, 1928

*GOOCH, W. T. 808 Speight Avenue, Waco, Texas.......... Apr. 29, 1925
*GOOD, TIMOTHY W. Supt. Water Works, Cambridge, Mass... Feb. 7, 1920
*GOODELL, J. E. Chmst., 444 Woolworth Bldg., Lancaster, Pa. Apr. 4, 1924
*GOODNOUGH, X. HENRY. Chief Engr. Dept. of Public Health, Room 141, State House, Boston, Mass.......... Feb. 2, 1924
*GORDON, Fred G. Monadnock Bldg., Chicago, Ill.......... June 8, 1921
GORDON, L. O. Mgr. Operations & Engineering, Peoples Light & Power Corp., 27 William St., New York, N. Y.......... Mar. 10, 1927
*GORE, WILLIAM. Cons. Engr., Confederation Life Bldg., Toronto, Ont.......... Mar. 30, 1910
GORMAN, ARTHUR E. Chicago Sanitary District, 6743 Olympia Ave., Chicago, Ill.......... Mar. 25, 1924
*GOSLAU, JUSTUS. Cedar Grove, N. J.......... May 13, 1924
*GOUDEY, RAY F. Resident Engr., State Dept. of Health, 823 Sun Finance Bldg., Los Angeles, Calif.......... Apr. 30, 1918
*GOULD, RICHARD H. Sanitary Engineer, Woolworth Building, Room 850, 233 Broadway, New York, N. Y.......... Feb. 6, 1924
*GRAF, AUGUST V. Chemical Engineer, St. Louis Water Works, 34 E. Grand Ave., St. Louis, Mo.......... June 15, 1914
*GRAHAM, JAMES W. 16 Casco St., Portland, Maine.......... June 4, 1912
*GRAM, ANDREW L. California Water Service Co., Redondo Beach, Calif.......... Jan. 26, 1928
*GRANT, L. MURRAY. Supt. Water Department, 531 County-City Bldg., Seattle, Wash.......... Feb. 5, 1927
GRANT, W. K. Municipal Engineer, Louisiana Fire Prevention Bureau, 619 Hibernia Bank Bldg., New Orleans, La.......... May 12, 1925
GRAY, A. C. Water Well Contractor, 28 Grant Street, St. Augustine, Fla.......... Jan. 31, 1927
*GRAY, WILLIAM J. Supt. & C.E., Springfield City Water Co., Post. Box 292, Springfield, Mo.......... Apr. 23, 1924
*GREELEY, SAMUEL A. #6 N. Michigan Ave., Rm. 1710, Chicago, Ill.......... July 11, 1907
GREEN, E. W. Sect., San Jose Water Works, 374 W. Santa Clara St., San Jose, Calif.......... Oct. 27, 1925
*GREEN, F. W. Supt. Filtration & Pumping, Passaic Consolidated Water Co., Little Falls, N. J.......... Dec. 22, 1915
*GREEN, PAUL EVANS. Civil & Sanitary Engineer, 400 N. Michigan Ave., Chicago, Ill.......... Apr. 14, 1915
*GREEN, RALPH H. Supt. of Water Works, P. O. Box 103, Morrison, Ill.......... Sept. 12, 1924
*GREEN, T. C. City Filtration Plant, Austin, Texas.......... Apr. 27, 1925
*GREENFIELD, R. E. Chemist, A. E. Staley Mfg. Co., 1002 W. Tuttle St., Decatur, Ill.......... Nov. 22, 1926
GREENLEE, J. L. Engineer, Asst. to Superintendent, Charlotte Water Works, Charlotte, N. C.......... June 17, 1926
*GREER, FRANK E. 5458 Kimbark Ave., Chicago, Ill.......... Sept. 23, 1927
GREER, WILLARD N. Research Chemist, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.......... Apr. 29, 1926
*GREGORY, JOHN HERBERT. Cons. Engr., Prof. Civ. & San. Eng., The Johns Hopkins Univ., Baltimore, Md.......... Apr. 1, 1910
GREIG, WILLIAM B. Municipal Engr., Point Grey, B. C., 5851 West Boulevard, Vancouver, B. C.......... June 11, 1928
*GRIFFEY, H. A. Mgr. Water Dept., City Hall, Janesville, Wis.......... June 14, 1920
GRIFFIN, GUY E. 50 Irving St., Cambridge, Mass.......... July 12, 1926
GRIFFIN, H. K. Div. Mgr., California Water Service Co., Stockton, Calif.......... Sept. 26, 1927

GRIFFIN, W. G. Supt., The Frankfort Water Co., Frankfort, Ky.	Mar. 27, 1925
*GRIFFITHS, JAMES G. Supt., Kensington Water Co., Box 143, New Kensington, Pa.	Oct. 31, 1924
*GRIME, EDWIN M. Engineer of Water Service, Northern Pacific Railway, St. Paul, Minn.	July 10, 1926
*GRIMES, EDWIN L. Mgr., J. B. McCrary Eng. Corp., 798 Vedado Way, N. E., Atlanta, Ga.	Feb. 23, 1920
*GRIMMER, ALLAN K. Town Engineer, Riordon Co., Limited, Temiskaming, Que., Can.	June 2, 1920
GROBBEL, DANIEL CORNELIUS. Asst. Secty., Bd. Wtr. Comnrs., Detroit, Mich.	Oct. 17, 1920
*GROENIGER, WILLIAM C. Cons. San. Engr., 503 Franklin Bldg., Columbus, O.	May 8, 1922
GRONER, E. C. 4300 W. Lake St., Chicago, Ill.	Oct. 11, 1923
GROSS, C. P. Mgr., Water & Electric Department, Box 87, Wisconsin Rapids, Wis.	July 31, 1924
GROSS, DWIGHT D. Board of Water Commissioners, Box 629, Denver, Colo.	July 29, 1925
GROTZ, WILLIAM H. Extension Dept., Bureau of Water, 50 Lakeview Ave., Buffalo, N. Y.	June 8, 1921
GRUETZMACHER, CLARENCE S. 2108-26th St., Milwaukee, Wis.	June 5, 1920
GUINEY, EDWARD J. Water Commissioner of Somerset, Box 592, Fall River, Mass.	June 6, 1927
GUNTER, HERMAN. State Geologist, P. O. Box 495, Tallahassee, Fla.	May 11, 1928
GUSHEE, EDWARD G. 5119 Greene St., Germantown, Philadelphia, Pa.	May 12, 1908
GWILLIM, E. C. City Engineer, Box 130, Sheridan, Wyo.	Mar. 6, 1926
*HABERMEYER, GEORGE CONRAD. Civil & Sanitary Engr., 57 Chemistry Bldg., Urbana, Ill.	Apr. 14, 1915
HABESHIAN, YERANOS B. Chemist, Filtration Plant, W. 32nd & Division Ave., Cleveland, Ohio.	Sept. 28, 1926
HACKETT, LEWIS E. 313 N. Capitol Ave., Lansing, Mich.	May 28, 1924
HAGINS, C. E. 314 Luzerne St., Westmont, Johnstown, Pa.	Sept. 7, 1926
HAHN, WALTER G. Local Manager, Illinois Power & Light Corp., Marseilles, Ill.	Mar. 31, 1928
*HALE, FRANK E., PH.D. Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y.	May 12, 1908
HALE, RICHARD A. Chief Engineer, Essex Company, Lawrence, Mass.	May 28, 1924
HALE, RICHARD KING, C.E. 545 Chestnut Hill Ave., Brookline, Mass.	June 10, 1911
HALL, ARTHUR J. Bacteriologist & Plant Supt., 316 W. Prospect St., Appleton, Wis.	Jan. 21, 1927
HALL, H. F. Chf. Engr., Water Works Dept., Northern Apts., Sarnia, Ont., Can.	June 21, 1920
HALL, H. G. Supt. Pub. Util. Comn., Ingersol, Ont., Can.	Mar. 26, 1923
HALL, HARRY R. Dpty. Chf. Engr., Washington Suburban Sanitary District, Hyattsville, Md.	May 8, 1915
*HALL, JOHN W. Supt., Choteau, Montana.	May 23, 1925
*HALL, ROLAND B. 705 Myrtle St., N. E., Atlanta, Ga.	Sept. 22, 1925
*HALPIN, THOMAS F. c/o A. P. Smith Mfg. Co., East Orange, N. J.	July 18, 1901
*HAMILTON, CHAS. A., M.E. Giffels, Hamilton & Weeber, 624 Grand Rapids Natl. Bank Bldg., Grand Rapids, Mich.	Dec. 29, 1926
HAMILTON, KENNETH. Mgr. Hamilton Heath Water Co., Chairman, Tampa Water Committee, 57 Hamilton Heath, Tampa, Fla.	Apr. 30, 1928

HAMMERLY, FRED V. 536 Call Bldg., San Francisco, Calif.... Jan. 2, 1924
HAMMOND, R. B. Supt. Water Dept., Blue Island, Ill........ June 8, 1919
*HAMMOND, W. H. Supt., Lindsay Water Works, Lindsay, Ont., Can........ June 24, 1914
*HANCOCK, EDWIN. Cons. Engr., 1509 Jackson Blvd., Chicago, Ill........ Nov. 12, 1919
HANLEY, J. D. Engr. & Contractor, 1st & Cedar Sts., Kelso, Wash........ Dec. 13, 1927
HANLEY, JOHN P. Inspector Water Service, Water Dept. Ill. Central R. R. Co. I. C. Sta., Chicago, Ill........ Mar. 13, 1925
HANNA, DAVID McLEAN. Service Supt., City Hall, Windsor, Ont., Can........ June 9, 1920
*HANNAN, FRANK. Chemist, Filtration Plant, 285 Willow Avenue, Toronto-8, Ont., Canada........ July 30, 1921
*HANSEN, A. E. Hyd. and San. Engr., 116 W. 39th St., New York, N. Y........ Dec. 31, 1917
HANSEN, J. C. Water Works Trustee, 551 West Broadway, Council Bluffs, Iowa........ Feb. 27, 1924
*HANSEN, PAUL. c/o Pearse, Greeley & Hansen, #6 N. Michigan Ave., Rm. 1710, Chicago, Ill........ June 4, 1912
*HARDER, E. C. Sect., American Bauxite Co., 1111 Harrison Bldg., Philadelphia, Pa........ Oct. 16, 1924
*HARDER, H. J. Civ. & San. Engr., 129 Market St., Paterson, N. J........ Dec. 4, 1920
*HARDIN, EUGENE A. Engineering Division, 8100 W. Warren Ave., Detroit, Mich........ Nov. 10, 1925
HARDING, GEORGE. Mgr., 1105 Paulsen Building, Spokane, Wash........ Oct 10, 1912
*HARDING, JAMES C., JR., C.E. 170 Broadway, New York, N. Y........ June 6, 1922
*HARDY, EDWARD DANA. Asst. Engr., United States Engineer's Office, Navy Dept. Bldg., Room 1716, Washington, D. C........ May 12, 1908
HARGER, FRANK D. Chief Operator, City Filtration Plant, 1249—8th St., Columbus, Ind........ Apr. 10, 1926
HARPER, L. V. Mgr., Chelan Electric Co., Chelan, Wash.... Aug. 19, 1914
*HARRIS, HOWARD A. Asst. Engr. California Water Service Co., 412 Hunter-Dulin Bldg., San Francisco. Cal........ Aug. 15, 1927
HARRIS, R. C. Commissioner of Works, City Hall, Toronto, Ont., Can........ May 12, 1914
HARRIS, SHIRLEY W. Mgr., McWane Cast Iron Pipe Co., Rm. 1288, 208 La Salle St., Chicago, Ill........ Feb. 17, 1927
HARRISON, RONALD. B. A. Sc., Engr. & Supt. Scarboro Twnshp. Water Works, Birch Cliff, P. O. Toronto, Canada........ Jan. 30, 1924
*HARRUB, C. NELSON. 705 Fourth & First Ntl. Bnk. Bldg., Nashville, Tenn........ Apr. 16, 1914
HARSHBARGER, ELMER DWIGHT. Pres., Pitt Construction Co., 239 Gladstone Rd., Squirrel Hill Sta., Pittsburgh, Pa... June 28, 1924
*HARTMANN, F. W. City Manager, Alma, Mich........ July 20, 1925
HARTWELL, OLIVER W. Dist. Engr., U. S. Geological Survey, State House, Trenton, N. J........ Jan. 24, 1928
*HASKINS, CAPT. CHAS A. Consulting Engineer, 517 Finance Bldg., Kansas City, Mo........ June 19, 1924
*HATCH, ARAM H. Chief Chemist in charge of Water Purification Plants of Canal Zone, P. O. Box 283, Ancon, Canal Zone........ Aug. 20, 1927
*HATCH, DONALD M. 610 Wildwood Ave,. Jackson, Mich..... May 16, 1920

*HATCH, THEODORE. 112 Pierce Hall, Harvard University, Cambridge, Mass. .... Jan. 6, 1926
*HATFIELD, WILLIAM DURRELL. Sewage Disposal Plant, Sanitary District of Decatur, Decatur, Ill. .... Jan. 31, 1917
HAUPT, B. W. Secty., Roaring Creek and Bear Gap Wtr. Cos., 204 E. Sunbury St., Shamokin, Pa. .... Mar. 16, 1922
*HAVENS, WILLIAM L. Associate, Geo. B. Gascoigne, 1149 Leader Bldg., Cleveland, Ohio .... June 5, 1926
HAVILL, HAROLD THOMAS. Asst. Engr., Dept. Wtr. Sup. N. Y. C., 51 North St., Mt. Vernon, N. Y. .... June 11, 1902
*HAWKINS, HORACE C. Supt., Municipal Water Plant, Oskaloosa, Iowa .... Nov. 4, 1926
*HAWLEY, GEO. W. Engr. in Charge, Water Supply Investgn. & Constn., East Bay Water Co., Oakland, Calif. .... June 30, 1922
HAWLEY, GEORGE W. Secty. & Treasr. Water Co., Dixon, Ill. June 21, 1920
*HAWLEY, JOHN B. Cons. Engr., 403 Cotton Exchange, Ft. Worth, Tex. .... June 1, 1923
HAWLEY, W. C. Chf. Engr. & Genl. Supt., Pennsylvania Water Co., 712 South Ave., Wilkinsburg, Pa. .... Apr. 27, 1910
*HAYDOCK, CHARLES. 2726 West Somerset St., Philadelphia, Pa. .... Feb. 17, 1919
*HAYFORD, B. B. Superintendent Water Works, Waukesha, Wis. .... June 8, 1909
HAYS, C. D. Huron, South Dakota .... Oct. 31, 1922
HAYWOOD, G. C. Secy., Metropolitan Water Supply Dept., 56 James St., Perth, W. Australia .... Oct. 6, 1915
*HAZEN, ALLEN. Civil Engineer, 25 W. 43rd St., New York, N. Y. .... May 27, 1896
*HAZLEHURST, GEORGE H. Chf. San. Engr., Montgomery, Ala. Nov. 1, 1914
HEALEY, THOMAS. Supt. Davenport Water Co., 206 Kahl Bldg., Davenport, Iowa .... May 28, 1924
HEARD, ALBERT. Supt. & Treas. Water Works, Hagerstown, Md. .... July 18, 1907
*HEATER, R. O. Mgr., Heater Well Drilling Co., Cary, N. C. .. Dec. 29, 1924
*HEATH, RAY. Laboratories of Dept. of Health, City Hall, Toronto, Canada .... June 26, 1924
HEBBRING, A. W. Supt. Wauwatosa Water Works, 292 Kenyon Ave., Wauwatosa, Wis. .... Sept. 8, 1923
*HECHMER, CARL A. Dept. Engr., Mtnce. & Optg. Dept., Wash. Subn. San. Dist., Hyattsville, Md. .... Nov. 3, 1919
HEERMANS, H. C. Manager Water Works Co., Hoquiam, Wash. .... June 26, 1886
HEFFERNAN, DAVID A. Supt. Water Dept., Milton, Mass. .... May 28, 1924
HELLING, HARRY A. Supt., Consol. Water Co., 86 Beekman St., North Tarrytown, N. Y. .... Jan. 17, 1922
*HELMREICH, L. W. Supt., Capital City Water Co., Box 32, Jefferson City, Mo. .... Feb. 14, 1927
HELWICK, J. W. V. P. & Gen. Mgr., Oregon-Washington Water Service Co., 701 Corbett Bldg., Portland, Ore. .... May 24, 1927
*HENBY, WM. H. Pres., St. Louis County Water Co., 6600 Delmar Ave., St. Louis, Mo. .... May 6, 1915
*HENDERSON, CHARLES R. Mgr. Davenport Water Co., Davenport, Iowa .... June 18, 1901
HENDERSON, CLARK T. Chairman Water Commission, 317 Chapin Lane, Burlingame, Calif. .... Mar. 10, 1926
HENDRICK, WALLACE M. 331 Madison Ave., New York, N. Y. .. May 10, 1915
*HENDRICKS, R. W. Engr. Hyd. Dept. Undtrs. Labs., 207 E. Ohio St., Chicago, Ill. .... Apr. 2, 1923

HENDRY, W. A. Chf. Engr., Water Works, 628 West 9th St., Waterloo, Ia. .... Nov. 25, 1921
HENSHAW, FRANKLIN. Supt. Water Works, Scarsdale, N. Y.. Sept. 21, 1920
*HERR, J. O. Manager, Monmouth Consolidated Water Co., Long Branch, N. J. .... June 5, 1916
HESS, EDWIN WESLEY. Cons. Engr., 2–6 Murray Bldg., Clearfield, Pa. .... Jan. 16, 1920
HETZER, MENTOR. Mgr. Moundsville Water Co., Moundsville, W. Va. .... Nov. 17, 1916
*HEVENOR, GLOSTER P. C. E., Hevenor & Weller, Inc., 5 St. Paul St., Rochester, N. Y. .... Nov. 10, 1927
HEYWARD, T. C., B.S. Mech. & Elect. Engr., 1100 Realty Bldg., Charlotte, N. C. .... June 22, 1923
HIBBARD, C. B. Vice-Pres., Peabody, Smith & Co., Inc., 38 Wall St., New York, N. Y. .... Sept. 27, 1928
*HIBBS, ALBERT S. Ass't Supt., Akron City Water Works, Municipal Bldg., Akron, Ohio. .... Sept. 12, 1922
HIBSCHMAN, CHARLES A. Supt., Ambler Spring Water Co., Ambler, Montgomery Co., Pa. .... Aug. 11, 1924
*HICKOX, J. R. Hyd. Engr., Chicago, Burlington & Quincy R. R., Room 1501, Burlington Bldg., 547 W. Jackson Blvd., Chicago, Ill. .... June 17, 1926
*HIGGINS, LAFAYETTE, C.E., 1144 W. 25th St., Des Moines, Iowa. .... Dec. 10, 1915
*HIGHLAND, SCOTLAND G. General Manager, Clarksburg Water Board, Clarksburg, W. Va. .... Feb. 10, 1913
*HILL, ALBERT B. Cons. C.E., 100 Crown St., New Haven, Conn. .... Oct. 30, 1914
*HILL, HARRY PRESCOT. 40 Kennedy St., Manchester, England. .... Nov. 6, 1924
*HILL, JOHN W. Cons. Engr., Brotherhood Bldg., Cincinnati, Ohio. .... June 26, 1886
*HILL, NICHOLAS S., JR. Cons. Engr., 112 E. 19th St., New York, N. Y. .... June 18, 1901
HINCHMAN, T. H. Cons. Engr., 800 Marquette Bldg., Detroit, Mich. .... June 1, 1923
*HINMAN, JACK J., JR. Assoc. Prof. of Sanitation, Univ. of Iowa, P. O. Box 313, Iowa City, Iowa. .... Apr. 21, 1915
*HOAD, PROF. WILLIAM CHRISTIAN. 1028 Martin Place, Ann Arbor, Mich. .... June 24, 1913
HOAG, GEORGE E. Fire Prevention Engineer, New York Fire Insurance Rating Organization, Suburban Division, 85 John St., New York, N. Y. .... June 2, 1920
HOAG, PERCY LATOURETTE. Hyd. Engr., Manhasset, L. I., N. Y. June 28, 1919
HOAGLAND, IRA GOULD. Secty., National Automatic Spklr. Assn., 80 Maiden Lane, New York, N. Y. .... Apr. 27, 1910
*HOBGOOD, A. B. Supt. of Water Works, Apex, N. C. .... Oct. 29, 1927
*HODGES, GEORGE C. Chemist, Consolidated Water Co., 712 Washington St., Utica, N.Y. .... June 11, 1924
HODGMAN, BURT B., C.E. 50 Church St., New York, N. Y. .... July 18, 1907
HODKINSON, THOMAS. C.E., Supt. Water Works, 14 King St., London, Ont., Can. .... Apr. 15, 1913
HOFFMAN, FLOYD A. Supt. of Water Dept., Box 413, Morristown, N. J. .... July 12, 1926
HOFFMASTER, GEORGE EDWARD. 32 Grove Ave., Larchmont, N. Y. .... May 13, 1916
HOGAN, JOHN PHILIP. Cons. Engineer, 84 Pine St., New York, N. Y. .... June 9, 1920

*Holbrook, A. A. General Mgr., Stroudsburg Water Supply Co., Stroudsburg, Pa. .... Jan. 14, 1925
Holbrook, Arthur R., C. E. Fuller & McClintock, 170 Broadway, New York, N. Y. .... Apr. 30, 1923
Holdredge, L. I. The Duro Co., 50 Church St., New York, N. Y. .... Jan. 1, 1926
*Holdredge, Neil C. P. O. Box 615, Haskell, N. J. .... May 26, 1924
*Holdsworth, Victor. 4 Corporation St., Dewsbury, Yorks, England .... Sept. 3, 1925
*Holland, Ray Kingsbury. Consulting Engineer, 106 E. Liberty St., Ann Arbor, Mich. .... Jan. 17, 1919
Holman, E. T. Chief Inspector, Tenn. Inspec. Bur., 1034 Stahlman Bldg., Nashville, Tenn. .... Jan. 7, 1924
*Holmes, J. A. Chief Chemist, Chicago Chemical Co., 6216 W. 66th Place, Chicago, Ill. .... May 25, 1926
*Holmquist, C. A. State Dept. of Health, Albany, N. Y. .... Apr. 27, 1923
*Holtz, J. B. Water Commissioner, Dillon, Mont. .... Jan. 17, 1927
Holway, A. S. 936 N. Michigan Ave., Chicago, Ill. .... June 9, 1921
Holway, W. R. Lock Joint Pipe Co., Ampere, N. J. .... Feb. 18, 1925
*Hommon, Harry B. Sanitary Engr., U. S. P. H. S., 420 Call Bldg., San Francisco, Cal. .... July 27, 1921
Honness, George Gill. 293 Wall St., Kingston, N. Y. .... Apr. 4, 1924
Hooper, Thomas H. Supt. Water Works, Winnipeg, Manitoba, Canada .... Mar. 5, 1924
Hoopes, Edgar M., Jr. Water Comnr., Box 895, Wilmington, Del. .... Apr. 10, 1923
*Hoot, Ralph A. Supt., Filter Plant, Highland Park Water Dept., Highland Park, Mich. .... Mar. 10, 1926
*Hoover, Charles P. Chemist, Filtration Plant, Columbus, Ohio .... May 14, 1913
*Hoover, Clarence B. Supt. Wtr. & Swge. Disp., 6th and Broad Sts., Columbus, Ohio .... Apr. 18, 1923
*Hopkins, Charles Comstock. Hydraulic and Sanitary Engr., 349 Cutler Building, Rochester, N. Y. .... June 10, 1911
*Hopkins, Edward S. Montebello Filters, Hillen Road, Baltimore, Md. .... June 13, 1921
*Hopkins, Edwin W. Consolidated Water Co., 712 Washington St., Utica, N. Y. .... Aug. 13, 1925
*Hopkins, Franklyn C. Prest. Consol. Water Co., 712 Washington St., Utica, N. Y. .... June 16, 1919
*Hopkins, Newton F. Civil Engineer, 801 Home Trust Bldg., Pittsburgh, Pa. .... July 18, 1907
Hopper, Walter C. Supt. Passaic Consol. Water Co., 145 Prospect St., Passaic, N. J. .... June 10, 1911
Horne, Alfred Dewey. 4820 Fletcher St., Chicago, Ill. .... Nov. 12, 1920
Horne, Ralph W. Fay, Spofford & Thorndike, 44 School St., Boston, Mass. .... May 26, 1928
Horner, Charles M. Supt. Water Works Co., 1705 State St., East St. Louis, Ill. .... June 24, 1903
Horner, H. H. Vice Pres. & Supt., The Birmingham Water Works Co., 2114 1st Ave., Birmingham, Ala. .... Dec. 29, 1924
*Horning, Fred A. Mgr., Superior Elec. Light & Water Works, Superior, Mont. .... Apr. 10, 1926
Horstmann, F. B. Chemical Engineer, 1005 N. Leamington Ave., Chicago, Ill. .... Jan. 20, 1911
Horton, Robert E., H.E. R. D. #1, Voorheesville, N. Y. .... Jan. 20, 1911
*Horton, Theodore. Chf. San. Engr. Dept. of State Engineering, 346 State St., Albany, N. Y. .... July 18, 1907

HOSKINSON, CARL M. Chief Engineer, Sacramento Filtration Plant, Sacramento, Calif. June 29, 1928
HOSTETLER, ERVIN W. Supt. of Distribution, Iowa City, Iowa. June 6, 1927
*HOTCHKISS, HARRY E. 795 Chenango St., Binghampton, N. Y. Mar. 16, 1927
*HOUGH, LAURENCE C. Dist. Mgr. Pitometer Co., 55 Bourne St., Jamaica Plain, Mass. Jan. 17, 1919
*HOUSER, GEORGE C. Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass. Nov. 24, 1925
*HOUSTON, L. J., JR. City Mgr., Fredericksburg, Va. Feb. 17, 1919
*HOWARD, CHARLES D. Chemist, State Bd. of Hlth., Concord, N. H. Feb. 18, 1921
*HOWARD, JOHN L. Ashburton Place, Boston, Mass. May 31, 1924
*HOWARD, N. J. Bacteriologist in Charge, Water Purif., Island Filtration Laboratories, 410 Lake Shore, Centre Island, Toronto, Ont., Canada. June 21, 1920
*HOWE, J. PARNELL. Engineer, Town of Pembroke, Pembroke, Ont. Mar. 10, 1928
*HOWE, M. J. Supt., Bd. Water Comnrs., Lake City, Minn. Feb. 11, 1922
*HOWELL, DAVID J., C.E. Union Trust Building, Washington, D. C. Oct. 10, 1914
HOWLAND, E. ROBERT. The British Pitometer Co., 39 Victoria St., London, S. W. I., England. Apr. 22, 1914
*HOWLAND, J. HASTINGS. Engr., National Board of Fire Underwriters, 85 John St., New York, N. Y. May 15, 1924
*HOWSON, LOUIS R. Alvord, Burdick & Howson, 130 Eighth Ave., LaGrange, Ill. Apr. 24, 1916
HOY, JOSEPH A. Asst. Genl. Foreman, Water Dept., 18 East Worcester St., Worcester, Mass. May 15, 1922
HUBBARD, A. M. Supt., Municipal Water Dept., Box Letter H, Troy, Montana. Nov. 10, 1925
*HUBBELL, CLARENCE W. Cons. Engr., 2640 Buhl Bldg., Detroit, Mich. June 24, 1903
HUDSON, JOHN. Compania Aguas Corrientes, San Nicolas, F. C. C. A., A. R. Aug. 19, 1924
*HUDSON, LEO. 802 Wabash Bldg, Pittsburgh, Pa. July 7, 1913
HUGGANS, R. D. Mgr. Water Works, Streator, Ill. Apr. 19, 1915
*HUGHES, W. P. City Engr. & Water Supt., City Hall, Lewiston, Idaho. Sept. 18, 1925
*HUGHES, WILLIAM JAMES. Asst. Engr. for Maintenance, Melbourne & Metropolitan Board of Works, 110 Spencer St., Melbourne, Victoria, Australia. Sept. 7, 1927
*HUMASON, N. J. Supt. of Filtration, Elyria Water Works, Lorain, Ohio. Mar. 13, 1925
HUME, W. R. Mechanical Engineer, c/o Hume Pipe Co., Melbourne, Australia. June 6, 1927
*HUMPHREYS, CHESTER C. Superintendent Filtration, Tampa Water Works, Tampa, Fla. June 17, 1926
HUNT, WM. G. Pump House Residence, R. R. No. 4, Peterborough, Ont., Can. Apr. 29, 1924
*HUNTER, CHARLES A., Asst. Dctr. State Hlth. Lab., Vermilion, S. Dak. July 18, 1923
*HUNTER, HENRY G. 598 Union Ave., Montreal, Canada. June 10, 1911
*HUNTER, T. B. Consulting Engineer, 41 Sutter St., Rm. 718, San Francisco, Calif. July 10, 1906
HUNTER, W. W. Supt., Canal & Water Works, Augusta, Ga. May 24, 1922
*HUNTINGTON, C. C. Box 613, Eureka, Kan. Mar. 19, 1927

HURD, CHARLES H. 1607 Merchants Bank Bldg., Indianapolis, Ind.......... Aug. 11, 1914
*HURDLE, REGINALD T. Supt. of Water & City Engr., Box 546, Glendive, Mont.......... July 6, 1926
HURLBUT, WILLIAM W. 207 South Broadway, Los Angeles, Calif.......... May 28, 1924
*HURTGEN, P. J. Director Public Works, City Hall, Kenosha, Wis.......... May 21, 1923
HUSE, GEORGE A. Treas. & Mgr., Northern Illinois Water Co., 132 S. Dearborn Ave., Kankakee, Ill.......... June 6, 1927
*HUTCHINS, WILL A. Secty. and Supt. Water Co., 196 Van Buren St., Freeport, Ill.......... Nov. 30, 1920
*HUTCHINSON, ALEXANDER, C.E. Dctr. Drummond, McCall & Co., P. O. Box 660, Montreal, P. Q.......... May 5, 1921
HUTSON, A. CARY. 85 John St., New York, N.Y.......... Apr. 29, 1924
*HUTTON, HAROLD S. Sanitary Engineer, 233 Oliver Ave., Pittsburgh, Pa.......... Apr. 1, 1920
*HUY, HARRY F. Genl. Mgr., Western New York Water Co., 11 Niagara St., 4th fl., Buffalo, N. Y.......... Apr. 13, 1916
*HYDE, CHARLES GILMAN. Cons. Hyd. & San. Engr., Prof. San. Eng., Univ. of Cal., Berkeley, Cal.......... July 18, 1907
HYDE, RALPH H. Vice President & General Manager, The Campbell Water Co., Box 1, Campbell, Calif.......... May 17, 1927
HYMAN, H. H. Mgr. Miami Water Co., Miami, Fla.......... Apr. 16, 1916

IGLEHART, H. B. Engineer, Water Dept., 206 City Hall, Houston, Tex.......... Apr. 6, 1928
*IHRIG, CHARLES O. Supt., Hazard Water Co., P. O. Box 1146, Hazard, Ky.......... Apr. 9, 1925
*INMAN, C. E. Comnr. & Supt. Water Works, Warren, O.......... May 24, 1921
INOUE, S. 290 Harajiku, Tokyo, Japan.......... July 18, 1907
ISAAC, F. N. Sec. G. M., The Hanford Water Co., Hanford, Cal.......... May 12, 1908
*IVANISSEVICH, L. Mitre 740, Mendoza, A. R.......... Jan. 6, 1927
IWASAKI, TOMIHISA. Water Wks. Dept., Suido Kakucho, Tokyo-Shiyakusho, Japan.......... Jan. 9, 1923

*JACK, GRANT R. Commissioner of Works, 787 Coswell Ave., Toronto, Ont., Canada.......... Mar. 16, 1926
JACKSON, C. B. Supt. City Water Corp., Fresno, Cal.......... Aug. 18, 1920
*JACKSON, DANIEL D. San. Expt., Havemeyer Hall, Columbia University, New York, N. Y.......... Jan. 31, 1910
*JACKSON, H. W. Supt. Water Works, 912 Arctic St., Antigo, Wis.......... Aug. 7, 1924
*JACKSON, JOHN F. Supt. Water Works Dept., 115 W. Fourth St., Rochester, Mich.......... May 23, 1923
*JACOBS, JOSEPH. Cons. C. E., 613-616 Thomson Bldg., Seattle, Wash.......... July 30, 1920
JACOBS, S. WILLARD. Chem. Engr., 9 East 41st St., New York, N. Y.......... Feb. 5, 1919
JACOBSEN, ROBERT T. Engineering News-Record, 10th Ave. & 36th St., New York, N. Y.......... Apr. 16, 1914
*JAHNS, L. O. Sanitary Engineer, 520—19th Ave., Moline, Ill.......... May 26, 1927
*JANZIG, ALEXANDER C. Wtr. Bact. & Chst. Filtn. Plant, 904 20th Ave., S. E., Minneapolis, Minn.......... Oct. 11, 1921
JARRETT, J. M. Supt. Water Works, Box 1602, Southern Pines, N. C.......... June 6, 1927

*JARVIS, CAPT. ALEXANDER CHARLES. Jens Kofoedsgade 4, Copenhagen, Denmark .... May 5, 1914
*JENKINS, DAVID. The New Jersey Zinc Co., Franklin, N. J. Oct. 14, 1922
JENKINS, E. J. Superintendent of Distribution, Philadelphia Suburban Water Co., Lansdowne, Pa .... Feb. 9, 1925
*JENKS, HARRY N. San. Engr., Assoc. Prof. Sanit. Engineering, Iowa State College, Ames, Iowa .... Jan. 26, 1917
*JENNE, LYLE L. Sanitary Engr., Bureau of Water, Philadelphia, Pa .... June 30, 1921
*JENSEN, J. ARTHUR. Supervisor Water Works Dept., Minneapolis, Minn .... Apr. 15, 1910
*JENSEN, J. CHRIS. Municipal Water Works, Council Bluffs, Iowa .... June 3, 1912
JETTE, JOS. ARTHUR. Asst. Supt. Montreal Water Works, 1509 Darling St., Montreal, P. O., Canada .... May 25, 1926
JEUP, B. J. T. Chf. Engr., Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind .... Feb. 22, 1920
*JEUP, BARNARD H. 2415 Talbott Ave., Indianapolis, Ind .. May 12, 1925
JEWELL, WILLIAM V. Chief Bkpr., Dept. of Streets & Public Impvts., 123 Clifton Place, Jersey City, N. J .... Nov. 10, 1927
JOHNS, HERBERT M. Supt. Hanford Water Co., Hanford, Calif .... Oct. 17, 1920
JOHNSON, EDGAR W. Asst. Engr., Water Dept., 3821 Elliot Ave., Minneapolis, Minn .... July 13, 1917
*JOHNSON, COL. GEORGE A. Cons. Engr., 150 Nassau St., New York, N. Y .... July 18, 1907
*JOHNSON, H. E. Supt. Public Utility Plant, Winona, Miss... Dec. 22, 1912
JOHNSON, H. V. Sect. Treas., Oregon-Wash. Water Service Co., 701 Corbett Bldg., Portland, Ore .... Jan. 18, 1928
JOHNSON, R. K. Dist. Sales Mgr., Darling Valve & Mfg. Co., 149 Broadway, New York, N. Y .... Jan. 18, 1928
*JOHNSON, SAMUEL C. Room 407, C. & O. Station, Huntington, W. Va .... Apr. 9, 1923
*JOHNSON, W. SCOTT. Division of Sanitary Engineering, State Board of Health, Jefferson City, Mo .... Feb. 16, 1924
*JOHNSTON, WILLIAM J. Supt. Water Works, Marquette, Mich. Mar. 10, 1917
*JONES, ALLEN A. Fuller & McClintock, 170 Broadway, New York, N. Y .... Feb. 23, 1924
*JONES, CARLTON W. Indus. & Munic. Engr., Alleghaney Ave., Towson, Balto. Co., Md .... May 5, 1928
JONES, EARL F. Mgr., Washington Water, Light & Power Co., Washington, Ind .... Mar. 23, 1927
JONES, F. WAYLAND. Water Works Supt., P. O. Box No. 112, Manteca, Calif .... May 24, 1927
*JONES, FRANK WOODBURY. Sanitary Chemist, 4293 E. 134th St., Cleveland, Ohio .... May 23, 1923
JONES, H. E. Brunner, Mond & Co., Ltd., Northwich, Cheshire, Eng .... Feb. 6, 1928
JONES, H. SEAVER. V. Prest., East Jersey Pipe Co., 7 Dey St., New York, N. Y .... July 16, 1922
*JONES, HARVEY P. 1601 Second National Bank Bldg., Toledo, Ohio .... July 30, 1922
*JONES, HIRAM F. Supt. Pumping & Filtration, Elmira Water Board, Elmira, N. Y .... July 18, 1907
JONES, J. M. Bristol & Warren Water Works, Bristol, R. I .... May 9, 1916
*JONES, MORRIS S. Asst. Chief Engr., Water Dept., City Hall, Pasadena, Calif .... Oct. 28, 1924
JONES, W. T. Superintendent Water Works, Hollywood, Fla. Dec. 11, 1922

*Jones, William Nelson. 8001-13th St., Tampa, Fla..... Apr. 14, 1914
*Joplin, Joseph W. 421 W. Emerson St., Princeton, Ind.... Feb. 9, 1925
Jordan, Frank C. Secretary Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind.................... June 10, 1911
*Jordan, Harry E. Sanitary Engr., Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind................ Oct. 7, 1919
Jordan, John G. Shields, Jordan & Roe, Engineers, 205 W. Wacker Drive, Chicago, Ill........................ June 6, 1927
Jorgensen, H. A. Supt., Municipal Water Works, 385 Elm Ave., San Bruno, San Mateo Co., Calif............ May 28, 1926
Judson, John W. Chf. Acct. Dpt. Sts. & Pub. Impvts., Newark, N. J...................................... June 12, 1920
Jutz, Charles E. Treas. St. Louis County Water Co., 6600 Delmar Ave., St. Louis, Mo........................ Apr. 12, 1920

*Kable, Edgar P. Genl. Mgr. York Water Co., 42 East Market St., York, Pa.................................. Nov. 10, 1917
*Kapp, John J., Jr. Supt., Municipal Water System, 378 Morrisse Ave., Haldeon, N. J......................... Mar. 29, 1927
Karl, Fred W. Chemical Engineer, Gypsy Oil Co., Tulsa, Okla.. Sept. 21, 1928
*Kay, Edgar B. Chf. Hyd. & San. Branch, Q. M. C., 1840 Mintwood Place, N. W., Washington, D. C........... Apr. 27, 1910
Kearns, L. J. Supt., Fort Madison Water Co., Fort Madison, Iowa.. Mar. 10, 1928
Keating, Charles Stanley. Deputy City Engr., State Tower Bldg., 10th fl., Syracuse, N. Y................. May 16, 1919
*Keckler, Clarence M. Sanitary Engineer, 21 Westside, Red Bank, N. J..................................... Sept. 14, 1927
*Keefer, Clarence Edward. Bureau of Sewers, Municipal Office Bldg., Baltimore, Md......................... Feb. 23, 1920
*Keenan, F. E. Superintendent of Water Wks., Gunnison, Colo.. Feb. 14, 1927
*Keils, Anthony. Supt., Mt. Clemens Water Works, 38 Moross Ave., Mt. Clemens, Mich...................... June 8, 1909
*Keis, F. J. Consulting Engineer, Sunset Building, Fort Lauderdale, Fla.................................. Apr. 23, 1927
*Keith, J. Clark. Chf. Engr., Essex Border Util. Comn., Murray Bldg., Windsor, Ont., Can.................. Mar. 21, 1923
Keliher, Timothy. Supt. Williamsport Water Co., Williamsport, Pa... Feb. 15, 1917
Keller, George John. Sect. & Gen. Mgr., Iowa City Water Co., Iowa City, Iowa.............................. Nov. 15, 1914
Keller, John N. Deputy County San. Engr. & Surveyor, 1126 Harding Drive, Toledo, Ohio................... May 12, 1925
Kelley, C. H. Supt. Wichita Water Co., 301 No. Main St., Wichita, Kans.................................... July 5, 1924
Kellner, Hugh. Chf. Engr. City Water Works, 74 Moy Ave., Windsor, Ont., Can............................. Feb. 28, 1923
*Kellogg, James Wilford. Bct. & Chst., State Lab. of Hyg., Raleigh, N. C................................ June 10, 1921
*Kelly, Earl W. Engineer, Water & Light Department, Duluth, Minn... Dec. 7, 1926
*Kelsey, J. W. Genl. Supt. Bureau of Water. St. Paul, Minn. May 13, 1913
Kemble, F. T. F. L. Putnam & Co., 111 Broadway, New York, N. Y.. June 24, 1915
*Kempkey, Augustus. Cons. Engr., 416 Hobart Bldg., San Francisco, Calif.................................. June 10, 1923

*KENDALL, ED. X. Supt. of Water Operation, Calif.-Oregon Power Co., Klamath Falls, Ore .... Jan. 12, 1928
KENDALL, THEODORE REED. Eng. Editor, *The American City*, 303 So. Broadway, South Nyack, N. Y. .... Mar. 13, 1919
*KENNEDY, C. C. Civil Engr., 543 Call Bldg., San Francisco, Calif .... Oct. 10, 1927
KENZLE, C. F. Asst. to Pres., Federal Water Service Corp., 27 William Street, New York, N. Y .... Aug. 17, 1927
KEOGH, WM. J. Asst. Engr. Dept. of Water, 9350-209th St., Queens, N. Y .... June 13, 1922
*KEPNER, DANA E. Director, Div. Sanitary Engineering, Colorado State Board of Health, 420 State Office Bldg., Denver, Colo .... Oct. 31, 1925
KERLIN, E. M. Sullivan, Indiana .... May 12, 1925
*KETCHAM, VALENTINE O. Gen. Mgr. Stamford Water Co., 51 Summer St., Stamford, Conn .... July 6, 1926
*KIENLE, JOHN A. Vice President, Mathieson Alkali Works, Inc., 250 Park Ave., New York, N. Y .... June 8, 1909
KIERNAN, MICHAEL J. 15 Caroline, Worcester, Mass .... Apr. 28, 1925
*KIERSTED, WYNKOOP, JR. 614 Interstate Bldg., Kansas City, Mo .... Apr. 27, 1925
*KILLAM, SAMUEL E. Supt. Distbn. Sctn. Wtr. Divn., 1 Ashburton Place, Boston, Mass .... Nov. 25, 1915
*KIMBERLY, A. ELLIOT. San. Engr., 8 E. Long St., Columbus, Ohio .... May 23, 1923
*KINDER, MYRON C. Commissioner of Water, City Bldg., Youngstown, Ohio .... Oct. 16, 1925
KING, ARNOTT CHISWELL. 94 Parmalee Ave., Hawthorne, N. Y .... Apr. 20, 1921
KINGMAN, HORACE. Comr. and Supt., City Hall, Brockton, Mass .... Mar. 17, 1916
KINGSLEY, JOHN F. Commissioner of Public Property, Covington, Ky .... June 9, 1920
KINTER, S. G. Supt., Water Co., Jersey Shore, Pa .... May 24, 1922
KIRBY, R. W. Manager, Mullens Water Works, Mullens, W. Va .... Oct. 7, 1924
*KIRCHOFFER, WILLIAM GRAY. San. & Hyd. Engr., 22 N. Carroll St., Madison, Wis .... Jan. 31, 1923
KIRKWOOD, LISTON. Inspector, Waterworks Dept., Public Util. Comn., Simcoe, Ont .... Feb. 28, 1928
*KITCHEN, H. B. Mgr. Watsonville City Wtr. Wks., 31 E. 3rd St., Watsonville, Calif .... Feb. 16, 1924
*KITE, ROBERT P. The Dorr Co., 1503 Candler Bldg., Atlanta, Ga .... Mar. 7, 1927
KITTREDGE, HARRY C. Consulting Engineer, 99-107 Oak St., Rochester, N. Y .... Mar. 30, 1926
*KIVELL, WAYNE A. Sanitary Engineer, Dorr Co., 310 South Michigan Ave., Chicago, Ill .... May 28, 1924
KLAPP, CARL F. Supt. Water Works, Everett, Wash .... Oct. 7, 1917
KLARE, R. W. Mgr., Northern Indiana Power Co., Wabash, Ind .... June 24, 1915
*KLAUS, FRED J. Chief Engr., East Bay Water Co., 512-16th St., Oakland, Calif .... Oct. 2, 1915
KLEIN, WILLIAM I. Cons. Engr., 41 Cortlandt St., New York, N. Y .... July 1, 1913
*KLINE, LESTER W. Gen. Mgr. Water Dept., 106 N. San Gabriel Blvd., San Gabriel, Calif .... June 1, 1927

KNEEN, A. H. Scranton-Spring Brook Water Serv. Co., 135 Jefferson Ave., Scranton, Pa. .... Jan. 8, 1911
KNICKERBACKER, JOHN, C.E. Pres. Eddy Valve Co., 86 First St., Troy, N. Y. .... June 24, 1913
*KNIGHT, G. WEBBER. Manager, Natrona Water Co., Natrona, Pa. .... Dec. 21, 1925
*KNIGHT, GERALD W. Consulting Sanitary Engineer, 147 Prospect St., Passaic, N. J. .... Nov. 25, 1925
*KNOUSE, HOMER V. Const. Engr., Metropolitan Utilities Dist., Utilities Bldg., 18th & Harney Sts., Omaha, Nebr. .. Sept. 21, 1918
*KNOWLES, CLARENCE R. Supt. Water Service, I. C. R. R., 6627 Woodlawn Ave., Chicago, Ill. .... June 4, 1913
*KNOWLES, MORRIS. Cons. Engr., 507 Westinghouse Bldg., Pittsburgh, Pa. .... July 18, 1907
KNOX, STUART K. 25 Warfield Street, Montclair, N. J. .... June 8, 1909
KNOX, W. H. Asst. Engr., State Dept., of Health, Columbus, Ohio .... Jan. 17, 1927
*KOHOUT, FREDERICK E. Supt., Short Hills Water Co., P. O. Box 291, Short Hills, N. J. .... Aug. 1, 1923
KOLB, JOHN KARL. Mgr., Elect. & Pump Dept., Fairbanks-Morse & Co., 630 W. Bay St., Jacksonville, Fla. .... Mar. 31, 1927
*KOON, RAY EMERSON. Stevens & Koon, Cons. Engrs., Spalding Bldg., Portland, Ore. .... Feb. 11, 1922
KORSCHEN, JOHN A. Commissioner of Public Works, City Hall, Middletown, N. Y. .... Feb. 18, 1925
KOSTER, ROY F. Hyd. Engr., Western Pipe & Steel Co., 5717 Santa Fe Ave., Los Angeles, Calif. .... Aug. 30, 1927
*KRAMER, WARREN A. The Dearborn Chemical Co., 1029 W. 35th St., Chicago, Ill. .... Mar. 29, 1927
KRIEGSHEIM, HEINRICH. The Permutit Co., 440 Fourth Ave., New York, N. Y. .... May 11, 1915
*KUESTER, JOHN H. Supt. Water Works, 370 Naymut St., Menasha, Wis. .... June 30, 1923
KUNIGK, W. A. Supt. Water Division, 2903 N. 26th St., Tacoma, Wash. .... Aug. 27, 1924
KUNKLE, CHARLES W. Supt. Johnstown Water Co., 229 Mifflin St., Johnstown, Pa. .... June 11, 1924
*KUNZ, S. F. Chf. Operator, Filter Plant, Water Dept., R. F. D., 6, Emporia, Kansas .... Feb. 18, 1927

*LAASE, WILLIAM F. 215 Myrtle Ave., Flushing, N. Y. .. May 28, 1924
*LABOON, JOHN F. Cons. Engr., 346 Bowerhill Road, Pittsburgh, Pa. .... May 23, 1923
*LABSAP, A. H. Water Supt., Longview, Wash. .... Dec. 13, 1927
*LACOUNT, H. O. Manager, Inspn. Dept. Factory Mutual Ins. Co., 124 College Ave., West Somerville, Mass. .... May 12, 1908
LAFLIN, ALBERT A. Supt. Water Works, St. Stephen, N. B., Can .... June 10, 1920
*LAFOREST, J. P. ALBERT. City Engr., City Hall, Longueuil, P. Q., Canada .... Sept. 26, 1928
*LAFRENIERE, THEO. J. San. Engr., Board of Health of P. Q., 59 Notre Dame, East, Montreal, Canada .... June 24, 1916
*LAMBERT, URBAN S. President, Alexandria Water Co., Alexandria, Va. .... Dec. 20, 1923
LAMEY, FRANK T. Supt. New Chester Water Co., 422 East 20th St., Chester, Pa. .... May 11, 1921
LAMPLEY, J. H. Mgr., Board of Water Commissioners, Hendersonville, N. C. .... Aug. 28, 1926

LANCTOT, THEO. City Engineer, Hull, P. Q., Canada........ Mar. 16, 1926
*LANDRETH, C. P. President, Direct Oxidation Process Co., N. W. Cor. 17th & Lehigh Ave., Philadelphia, Pa...... Jan. 6, 1926
LANE, FRED W. Superintendent Water Works, 1132 Locust St., St. Petersburg, Fla........ Oct. 7, 1925
*LANGELIER, WILFRED F. Assoc. Prof. San. Eng., Univ. of California, Berkeley, Calif........ Feb. 28, 1923
LANPHER, E. E. Managing Engr., Bureau of Water, 416 City-County Bldg., Pittsburgh, Pa........ Apr. 8, 1922
LAPOLT, HAROLD S. Deputy Collector, Water Dept., City Hall, Middletown, N. Y........ Feb. 14, 1925
*LARMON, FRANK P. Consulting Engineer, 1618 Beverly Road, Brooklyn, N. Y........ Apr. 17, 1914
*LASLEY, E. W. 2645 Dexter St., Denver, Colo........ Jan. 10, 1928
*LASSITER, LEROY IRVING. Sanitary Engineer, Consolidated Board of Health, Wilmington, N. C........ May 25, 1926
LASSO, ALFREDO F. Ing. Civ., Obras Sanitarias de la Nacion, Buenos Aires, R. Argentina........ Sept. 26, 1917
*LATHROPE, THOMAS R. Asst. Sanitary Engineer, State Dept. of Health, Columbus, Ohio........ Jan. 10, 1925
*LAUBER, H. M. Water Superintendent, Savannah, Mo........ Jan. 20, 1928
LAUNER, NELSON M. Superintendent, P. O. Box 117, La Habra, Calif........ Nov. 15, 1926
LAURENCENA, ALBERTO F. 25 de Junio Street 262, Parana, Argentine........ Apr. 21, 1928
*LAUTER, CARL J. Chief Chemist, Washington Filtration Dalecarlia Filter Plant, Washington, D. C........ Apr. 13, 1922
*LAUTZ, W. E. Secy. and Mgr., Pekin Water Works, Pekin, Ill........ Nov. 14, 1915
LAUX, PAUL C. Chemical Representative, National Lime Association, 35 South Monroe Ave., Columbus, Ohio........ Feb. 8, 1926
*LAWLOR, FRANCIS D. H. Supt. Citizens Water Co., Burlington, Iowa........ July 10, 1906
*LAWRENCE, E. A. Cons. Civ. & Munic. Engr., 511-12 Hartman Bldg., Columbus, Ohio........ Apr. 6, 1921
*LAWRENCE, FREDERICK H. 145 W. Sharpnack St., German town, Philadelphia, Pa........ Mar. 5, 1924
LAWRENCE, R. E. City Engineer, Chanute, Kan........ May 22, 1928
LAWRENCE, W. H. Supt. Water Works, Box 362, Kalispell, Mont........ Dec. 16, 1919
*LAWRENCE, WILLARD C. Supt. Filtration & Sewage Disposal, Baldwin Filters, Fairmount Road, Cleveland, Ohio........ June 17, 1926
*LAWTON, RALPH W. 137 No. Van Ness Ave., Los Angeles, Calif........ July 10, 1906
*LEA, WILLIAM S. Consulting Engineer, 340 University St., Montreal, Canada........ Jan. 26, 1924
*LEAF, WALTER B. Serv. Engr., Aluminate Sales Corp. of Chicago, 1649 Cherry St., Denver, Colo........ Mar. 19, 1928
LEAHY, THOMAS J. 546 Emerson St., Denver, Colo........ July 29, 1925
*LEARNED, ALBERT P. Asst. Engr., Black & Veatch, 701 Mutual Bldg., Kansas City, Mo........ May 15, 1922
LEBOLD, GEORGE. Supt. of Meters, Hackensack Water Co., 624 Park Ave., Weehawken, N. J........ Mar. 13, 1925
*LEDDEN, ERNEST M. 404 Fourth Ave., New York, N. Y........ Apr. 5, 1912
LEDOUX, J. W. Cons. Engr., 112 N. Broad St., Philadelphia, Pa........ July 18, 1907
*LEE, CHARLES E. Manager Placentia Water Company, Placentia, Calif........ Feb. 15, 1928

*LEE, CHARLES H. Cons. Hyd. Engr., 58 Sutter St., San Francisco, Calif. .... Mar. 21, 1912
LEE, SCOTT M. Supt. City Water Dept., 58 Newman Ave., Arcadia, Calif. .... June 6, 1927
*LEET, J. N. Supt. Water Dept., North East, Pa. .... May 4, 1911
*LEISEN, THEODORE A. Gen. Mgr. Metropolitan Utilities Dist., Utilities Bldg., Harney at 18th, Omaha, Nebr. .... June 7, 1904
*LENDALL, HARRY N. Engineering Dept., Rutgers Coll., New Brunswick, N. J. .... Mar. 6, 1923
LENHARDT, LAWRENCE G. Division of Engineering, Dept. of Water Supply, Water Works Park, Detroit, Mich. .... June 10, 1920
LENNON, EDWARD J. Supt. Water Works Dept., City Hall, Fort Wayne, Ind. .... Apr. 10, 1926
*LEONARD, W. D. Manager, Water, Light & Gas Plants, 101 N. Main St., Fort Atkinson, Wis. .... July 21, 1922
LEOPOLD, F. B. 407 House Bldg., Pittsburgh, Pa. .... May 11, 1914
*LEOVITT, W. F. Superintendent of Construction, Fresno City Water Corp., 1423 Weldon Ave., Fresno, Calif. .... Mar. 16, 1927
LE ROYER, E. Supt. Water Works, St. Lambert, Ont., Canada. Mar. 26, 1928
*LESAGE, THOMAS WILLIAM. Engr., Water Works Dept., City Hall, Montreal, Canada .... Apr. 24, 1916
*LESLIE, JAMES. Canada Fire Udtrs. Assn., Coristine Bldg., Montreal, Canada .... May 5, 1920
*LESSARD, C. CAMILLE, C.E. 32 Boulevard des Allies, Quebec, Canada .... Feb. 25, 1927
*LETTON, H. P. Grant, Fulton & Letton, Engrs., 525 South 13th St., Lincoln, Nebr. .... Dec. 23, 1914
*LEVINE, DR. MAX. Assoc. Prof. Bacteriology, Iowa State College, Ames, Iowa .... Nov. 30, 1921
*LEVY, A. G. Engr. Construc. & Surveys, Div. of Water, 9405 Hough Ave., Cleveland, Ohio .... May 17, 1910
*LEWIS, CHESTER F. Cons. Engr., c/o Spoon & Lewis, Box 990, Greensboro, N. C .... Apr. 23, 1924
LEWIS, JOHN V. 67 Normandy Ave., Rochester, N. Y. .... Feb. 18, 1921
*LIBBY, FRANK D. Chemist, Kalamazoo Vegt. Parch. Co., Kalamazoo, Mich. .... May 23, 1923
*LILLY, H. ALBERT. Chemist, Aluminum Co. of America, P. O. Box 356, Badin, N. C. .... July 19, 1927
*LILLY, JOHN. Assistant Waterworks Engineer, British Municipal Waterworks, Tientsin, North China .... Dec. 20, 1926
LIMB, JOHN MOZART. Chief Chemist, Western Aust. Govt. Railways, Midland Junction, W. Aust. .... Apr. 27, 1928
*LINDERS, ED. Engineer of Design, Water Dept., 601 City Hall, Cleveland, Ohio .... Oct. 16, 1925
LIRA, LEONARDO. Chf. Engr. of Inspt. Water Works, Casilla 492, Santiago, Chile .... Sept. 9, 1919
*LITCH, M. B. Chemist in charge of Filters, 631 Pine St., Steelton, Pa. .... May 1, 1922
*LITTLE, BEEKMAN C. 305 Cutler Bldg., East Avenue, Rochester, N. Y. .... June 24, 1903
LOCKWOOD, WILBUR D., C. E. 903 Second St., Peekskill, N. Y. .... Mar. 19, 1924
LOFTON, H. M. Chattanooga, Tenn. .... May 25, 1895
*LOGAN, C. G. Supt. Waterworks, Waynesville, N. C. .... Dec. 8, 1923
LONG, GEORGE J. Prest., Inter-State Water Co., P. O. Box 2360, Louisville, Ky .... May 24, 1915
LONG, JAMES H. Chief Engr., City Hall, Camden, N J. .... May 13, 1919
*LONGLAND, E. L. Supt., Municipal Water District, San Rafael, Calif. .... Apr. 10, 1924

Longley, F. F. Lock Joint Pipe Co., P. O. Box 21, Ampere, N. J. ... July 18, 1907
*Losee, James R. Engineer & Superintendent, Tarrytown Water Works, 65 Main St., Tarrytown, N. Y. ... July 28, 1928
*Loughran, James F. 74 John St., Kingston, N. Y. ... Jan. 19, 1926
Louison, Ben Howe. 654 Bergen Avenue, Jersey City, N. J. ... Oct. 26, 1927
*Lounsbury, Wm. C. Gen. Mgr., Superior Water, Lt. & Pwr. Co., Superior, Wis. ... May 12, 1908
Lount, C. A. Commissioner of Works, Cornwall, Ont., Canada ... Mar. 26, 1928
*Lourie, G. E. Water Works Supt., P. O. Box 388, Bristol, Conn. ... Sept. 20, 1923
*Lovejoy, Wm. H. Supt. Filtration, Louisville Water Co., Louisville, Ky. ... June 4, 1908
*Loveland, Chester H. Consulting Engineer, 908 Balboa Bldg., San Francisco, Calif. ... Oct. 22, 1924
Lovell, A. P. Gen. Formn., San Diego Wtr. Dept., 2516 San Marcos Ave., San Diego, Calif. ... Nov. 8, 1923
*Lower, J. R. Chemist-in-Charge, Bucyrus Water Works, Bucyrus, Ohio ... Sept. 28, 1927
*Lowther, Burton. Consulting Engineer, 316 Guardian Trust Bldg., Denver, Colo. ... June 21, 1921
*Luce, Arthur T. Federal Water Service Corp., 27 William St., New York, N. Y. ... Apr. 10, 1919
*Ludlow, J. L. Cons. Engr., Winston-Salem, N. C. ... June 7, 1904
*Luippold, G. T. Wallace & Tiernan Co., 304 Holm Bldg., 3923 W. 6th St., Los Angeles, Calif. ... Feb. 16, 1924
*Lundell, George R. Asst. Chemist & Bacteriologist, Fridley Filtration Plant, Minneapolis, Minn. ... Aug. 8, 1927
Lundberg, Eric. Water Works Supt., Galva, Ill. ... Sept. 25, 1923
*Luscombe, William. Vice Pres. Gary Heat, Light & Water Co., Gary, Ind. ... May 12, 1908
Luthy, Fred. Chf. Engr. Water Dept., Orange, N. J. ... June 8, 1921
*Lyle, Newton B. Supt. Clymer Water Co., Room 203, Savings & Trust Bldg., Indiana, Pa. ... June 17, 1926
Lyles, Joseph E. Chemist, Tampa Filtration Plant, Tampa, Fla. ... Jan. 1, 1927
Lyman, Richard R. Consulting Civil Engineer, 47 E. So. Temple St., Salt Lake City, Utah ... Dec. 18, 1924
Lynch, Thomas C. Supt., Rochester Water Works, Meter Dept., Dewey Ave., cor. Bloss St., Rochester, N. Y. ... Feb. 17, 1927
*Lyon, A. S. Supt. of Public Works, Rocky Mount, N. C. ... Dec. 8, 1923
*Lyon, Frank A. Supt. City Water Dept., 130 East St., Oneonta, N. Y. ... Oct. 16, 1924
*Lyon, Mrs. Frank A. Chemist & Asst. Supt., Water Department, 130 East St., Oneonta, N. Y. ... Dec. 15, 1925

McAdams, W. A. Supt. Water & Light Dept., Farmville, N. C. ... Dec. 8, 1923
*McAlary, Allan. Supt. & Treas. Camden & Rockland Water Co., Box 151, Rockland, Me. ... Apr. 18, 1922
McAlpine, A. H. Genl. Western Agt., Hersey Mfg. Co., 1557 E. Long St., Columbus, Ohio ... Apr. 27, 1889
*McAmis, James W. Supt., Water Works, Greeneville, Tenn. ... Sept. 12, 1921
McBurnett, B. B. Water Superintendent, City Hall, Chickasha, Okla. ... Feb. 2, 1924
McCaffery, Bernard J., M.E. Supt. of Water Works, South Bend, Ind. ... Mar. 10, 1926

McCaffrey, Wm. A. Supt. Water Works, 191 E. 6th St., Oswego, N. Y. .... June 21, 1920
*McCaleb, Wm. B. Gen. Supt. Wtr. Cos.. P. R. R., Coml. Trust Bldg., Rm. 922, Philadelphia, Pa. .... Sept. 30, 1919
*McCandless, Anderson L. Supt. Euclid Water Dept., Euclid, Ohio .... Feb. 8, 1928
*McCarthy, Owen A. Commissioner of Water Supply, City Hall, Fordson, Mich .... Mar. 3, 1927
McCarty, Edward C. California Water Service Co., 412 Hunter-Dulin Bldg., San Francisco, Calif .... July 11, 1927
*McClain, Carl A. Genl. Superintendent-Secretary, Eugene Water Board, Eugene, Ore .... Jan. 17, 1928
*McClaskey, George G. Consulting Engineer, 818 Renkert Building, Canton, Ohio .... June 9, 1921
McClellan, Thomas D. United Piece Dye Works, Lodi, Bergen Co., N. J .... Aug. 28, 1924
*McClenahan, W. T. 6218 University Ave., Chicago, Ill. .... Apr. 7, 1914
*McClintock, James R. 170 Broadway, New York, N. Y. .... Jan. 12, 1914
*McClure, Ira E. Supt. Water Works, P. O. Box 45, Columbus, Mont .... Mar. 27, 1925
*McConnell, Earle G. Mees & Mees, 616 Johnston Bldg., Charlotte, N. C. .... June 1, 1923
*McCrady, MacHarvey. Chmst. & Bact., Bd. of Hlth. of P. Q., 59 Notre Dame East, Montreal, Canada .... Apr. 7, 1916
*McCrea, T. R. Biologist, Morehead City, N. C. .... Aug. 28, 1926
McCrudden, D. A. Asst. to Chief, Bur. of Wtr., 796 City Hall, Philadelphia, Pa. .... July 7, 1920
*McCulloh, E. Engineer, 2320 Grand Ave., Minneapolis, Minn. .... May 27, 1922
McCulloh, Walter. Consulting Engineer, 406 Gluck Bldg., Niagara Falls, N. Y. .... Mar. 17, 1926
*McCurdy, H. S. R. Chf. Engr., Phila. Suburban Water Co., 762 Lancaster Avenue, Bryn Mawr, Pa. .... July 16, 1927
McCurdy, Howard. City Engineer & Supt. Water Works, 4305 Santa Fe Ave., Vernon, Calif .... Dec. 29, 1925
McDonald, John H. Pres. Bd. Water Comnrs., City Hall, St. Paul, Minn. .... June 19, 1920
McDonnell, Robert E. 402 Interstate Building, Kansas City, Mo. .... May 25, 1913
McEvoy, Edward F. 61 Winfield Ave., Jersey City, N. J. .... May 28, 1924
McFarland, Chester R. Secy. & Gen. Mgr., Tampa Water Works Co., Tampa, Fla. .... May 12, 1908
*McFaul, W. L. Mgr. Water Dept. & City Engr., City Hall, Hamilton, Ont., Canada .... Mar. 8, 1924
McGeehin, D. J. Supt. Wyo. Valley Water Supply Co., Markle Bank Bldg., Hazleton, Pa. .... June 11, 1916
McGonigale, Wm. J. P. O. Box 2360, Louisville, Ky. .... Apr. 5, 1912
McInnes, F. A. Cons. Engr., 264 Bay State Rd., Boston, Mass. .... May 12, 1914
McIntosh, William. P. O. Box 794, Santo Domingo City, Santo Domingo, R. D. .... Feb. 26, 1913
*McKaughan, O. M. Supt. Water Dept., Wake Forest, N. C. .... Dec. 8, 1923
McKay, John William. Deputy Chf. Engr. Dpt. W. S. G. and E., 170 College Ave., Boro. Rchmnd., New York. .... Feb. 19, 1920
*McLaren, Peter. Hydraulic Engineer, 501 N. Washington Ave., Whittier, Calif .... Oct. 13, 1926
McLaughlin, H. L. Salesman, National Meter Co., 1117 York St., Denver, Colo .... Mar. 10, 1926

McLaughlin, Philip L. Sanitary Engineer, 111 Halstead St., East Orange, N. J. .... July 12, 1928
McLean, R. F. Supt. of Water Dept., Walla Walla, Wash. .. June 29, 1928
McLeod, J. A. Asst. Chf. Insp., Bureau of Engineering, State Board of Health, Raleigh, N. C. .... Apr. 23, 1924
*McMillan, J. A. Manager Water Works, Charlottetown, P. E. I., Can .... Mar. 16, 1927
McMillan, W. Bruce. Chf. Engr., Thebo, Starr & Anderton, Inc., 523 Sharon Bldg., San Francisco, Calif. .... May 31, 1928
*McNamee, Robert L. Principal Assistant Engineer, Hoad, Decker, Shoecraft & Drury, State Sav. Bk. Bldg., Ann Arbor, Mich .... June 17, 1926
McNeil, J. L. Superintendent Water Works, Lumberton, N. C .... Aug. 28, 1926
McQueen, Leo E. Supt. Bd. Pub. Wks., Coldwater, Mich .... Apr. 13, 1923
McRae, J. Percy. c/o Sawyer-Massey Co., Hamilton, Ont., Canada .... Jan. 30, 1924
*McRae, John B. Cons. Engr., Jackson Bldg., Ottawa, Canada .... May 9, 1906
McReynolds, B. B. Supt. Water Wks., City Hall, Colorado Springs, Col .... May 25, 1914
*McVea, J. C. City Engineer, City Hall, Houston, Texas .... Nov. 6, 1924
McWane, J. R. Pres., McWane Cast Iron Pipe Co., Birmingham, Ala .... Feb. 26, 1926
McWilliams, D. E. Prest., Bear Gap Wtr. Co., Mgr. Roaring Creek Wtr. Co., Box 17, Shamokin, Pa .... Mar. 16, 1922
*McWilliams, Major John I. Camp Quartermaster, P. O. Box 1, Pine Camp, Great Bend, Jefferson Co., N. Y. ... July 22, 1928
*Mabee, William Curtis. Asst. Chief Engineer, Indianapolis Water Co., 113 Monument Cir., Indianapolis, Ind. Dec. 19, 1924
Macallum, Andrew F. Comnr. of Works & City Engr., City Hall, Ottawa, Ont., Canada .... Feb. 23, 1927
*MacCarty, A. City Commissioner, Box 115, Sheridan, Wyo. Feb. 18, 1925
*MacDonald, Emmett. Mgr., Illinois Water Service Co., Sterling, Ill .... June 7, 1904
MacDonald, W. B. Manager, Mountain States Power Co., Kalispell, Mont .... Feb. 23, 1926
*MacDonald, W. E. City Water Works Engineer, 21 Fourth Ave., Ottawa, Can .... May 8, 1917
MacKall, Murray R. Hyd. Engr., California Railroad Commission, State Building, Civic Center, San Francisco, Calif .... May 11, 1927
*MacKenzie, S. H. Engr. & Supt. Terryville & Southington Water Works, Southington, Conn. .... Apr. 14, 1916
Mackie, F. G. City Engineer, North Bay, Ont., Canada. .. Mar. 16, 1926
Macksey, Henry V. 68 Pleasant St., Framingham Centre, Mass .... May 28, 1924
MacNamee, Daniel F. Standard-Star Bldg., 55 Rose St., New Rochelle, N. Y .... Jan. 1, 1927
*MacNicol, N. Township Engineer, Township of Etobicoke, Islington, P. Q., Canada .... Mar. 16, 1926
Macqueen, Philip O. 5904 Dalecarlia Place, N.W., Washington, D. C .... May 28, 1924
Madison, James Talbott. Civil Engineer, P. O. Box 435, Lawrenceburg, Ky .... Apr. 26, 1926
*Maffitt, Dale L. Chemist, Des Moines Municipal Water Plant, Des Moines, Ia .... Apr. 2, 1918
*Maffitt, Howard C. Consulting Chemist, 526—11th St., Des Moines, Iowa .... Dec. 20, 1926

*Maffitt, M'Kean. Supt. Water & City Eng., Wilmington, N. C. .... Dec. 11, 1922
Magerstadt, Paul E. East Bay Water Co., 512 16th St., Oakland, Calif. .... June 23, 1922
Maggiolo, Carlos M. Engineer, Director of Dept. of Sanitation, Tristan Narvagas 1221, Montevideo, Uruguay. . May 22, 1928
*Mahlie, Winfield S. Chst. in Chge. Filtn. Plant, Fort Worth, Texas .... Feb. 28, 1923
Mahoney, Arthur Sawyer. City Engr., 94 Washington Ave. Clifton, N. J. .... July 18, 1923
*Main, Geo. A., M.E. Cons. Engr., 112 Baker St., Daytona, Fla. .... Apr. 27, 1910
Majeske, Joseph F. Supt. of Personnel Bureau, Dept. of Water Supply, Detroit, Mich. .... Oct. 4, 1927
Malcomson, Alfred S. Appraisal Engineer, 132 Nassau St., New York, N. Y. .... Jan. 1, 1928
*Male, Leonard H. State Sanitary Engineer, 122 Capitol Bldg., Salt Lake City, Utah .... Dec. 20, 1927
*Mallalieu, Capt. Willard C. Civil & Sanitary Engineer, Jersey City Water Works, Boonton, New Jersey .... Dec. 4, 1914
*Manahan, Elmer G. Cons. Engrs., Fuller & McClintock. 170 Broadway, Room 1512, New York, N. Y. .... June 8, 1909
*Manahan, Patrick. Supt. Water Works, Briarcliff Manor, N. Y. .... May 27, 1924
*Mangun, L. B. Chst. in Chge. of Water Purification, Kansas City, Kansas .... Feb. 23, 1920
*Mansfield, Myron G. Div. Engr., Morris Knowles, Inc., 507 Westinghouse Bldg., Pittsburgh, Pa. .... June 11, 1924
*Mantel, F. A. 1043 Greenlaw Ave., Memphis, Tenn. .... Mar. 5, 1924
Mapes, John B. Constr. Engr., 38 E. Post Rd., White Plains, N. Y. .... Apr. 16, 1923
*Mar, Y. C., C.E. c/o Antonio Perez, 9 Liau Ah Au Street, Amoy, China .... Dec. 24, 1925
*Mark, Coleman B. Dist. Engr. Pa. Dpt. of Hlth., 603 N. 3rd St., Harrisburg, Pa. .... May 3, 1923
*Markhus, O. G. F. Dist. Mgr., Wallace & Tiernan Co., Inc., 411 Lloyd Bldg., Seattle, Wash. .... Jan. 30, 1928
Marner, Paul B. Hyde Park, Y. M. C. A., 1400 E. 53rd St., Chicago, Ill. .... Sept. 13, 1926
Mars, A. D., Jr. Mgr., Neptune Meter Co., 1700—15th St., Denver, Colo. .... Dec. 16, 1926
*Mars, L. Donald. Asst. San. Engr., U. S. P. H. S., Jefferson, Ore. .... June 30, 1920
*Marsden, Raymond R. Dean, Thayer School of Civil Eng., Hanover, N. H. .... Jan. 26, 1925
Marsh, Francis B. Board of Water Supply, Municipal Bldg., New York, N. Y. .... May 19, 1924
*Marshall, Cyril E. Professional Civil Engineer, 266 Fulton Ave., Hempstead, N. Y. .... Aug. 12, 1924
Marshall, Hugh A. Aluminate Sales Corp., Union Stock Yards, Chicago, Ill. .... Oct. 7, 1924
Marshall, J. B. Chf. Engr. Tucker & Laxton, Inc., 900 Realty Bldg., Charlotte, N. C. .... Nov. 8, 1923
Marshall, John. Supt., Flagstaff Municipal Water Works, Flagstaff, Ariz. .... Sept. 29, 1925
*Marshall, L. A. Supt. Division Filtration Plant, Division Ave. & W. 32nd St., Cleveland, Ohio .... May 26, 1921
*Marston, Frank Alwyn. Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass. .... Feb. 20, 1922

*MARTIN, J. C. Attorney, Ohio Water Works Association, 414 Gasco Bldg., Columbus, Ohio.......... May 11, 1915
MARTINDALE, R. W. 909 Monadnock Bldg., San Francisco, Calif.......... Nov. 8, 1923
*MARTINEZ, ROLANDO A. Consulting Engineer, Obispo #59, Havana, Cuba.......... Dec. 20, 1927
MARVIN, GEORGE. Supt. of Water & Light Dept., Marshfield, Wis.......... Sept. 3, 1924
MARVIN, J. B. Sect. & Gen. Mgr. Frankfort Water Works Co., 259 North Jackson St., Frankfort, Ind.......... Dec. 29, 1924
*MARX, PROF. C. D. Civil Engineering, Stanford University, Cal.......... Nov. 6, 1924
*MASON, S. J. Engr. & Supt. Water Works, Perth Amboy, N. J.......... May 7, 1917
MASSEY, GEORGE B. Vice Pres., Randolph Perkins Co., Cons. Engrs., Room 1444, 33 So. Clark St., Chicago, Ill.......... June 17, 1926
*MASSINK, A. Chst. & Bact., Central Laboratory of Holland, Utrecht, Holland.......... July 20, 1921
MAST, JAMES E. Civil Engr., 519 Penn St., Reading, Pa.......... Feb. 20, 1925
*MATHEWS, WILLIAM W. 4223 Oakenwald Ave., Chicago, Ill.......... Nov. 18, 1925
*MATTE, HUBERT P. T. Coml. Engr., Worthington Pump & Machy. Corp., Harrison, N. J.......... July 26, 1913
*MATTER, L. D. District Engr., 56 West Union Street, Wilkes-Barre, Pa.......... May 3, 1923
*MATTESON, VICTOR ANDRE. Water Works, Architect, 1402 Hartford Bldg., Chicago, Ill.......... May 19, 1923
MATTHEWS, IRVING E. Superintendent, Bureau of Water, 43 City Hall, Rochester, N. Y.......... May 25, 1919
MAUCH, THEO. C. M. Supt. Pumping Stations, Indianapolis Water Co., Indianapolis, Ind.......... Dec. 29, 1924
*MAURY, LT. COL. DABNEY H. Consulting Engineer, 12 Quincy Street, Chevy Chase, Md.......... Aug. 22, 1894
MAUZY, ANDREW B. Water Conservator, City Hall, Jersey City, N. J.......... Dec. 8, 1922
MAVIS, F. THEODORE. 304 W. University Ave., Urbana, Ill.. Oct. 23, 1925
*MAXWELL, DONALD H. Prin. Asst. Engr., Alvord, Burdick & Howson, 1417 Hartford Building, Chicago, Ill.......... Feb. 15, 1917
MAY, CLYDE R., Gen. Supt. & Engineer, Water Dept., St. Paul, Minn.......... Sept. 10, 1928
*MAYO, W. T. Commr. of Public Utilities, P. O. Box 284, Shreveport, La.......... June 16, 1927
MAYO, WILLIAM B. c/o Ford Motor Co., Detroit, Mich.......... Aug. 16, 1917
MEAD, DANIEL W., C.E. 120 W. Gorham St., Madison, Wis.. Apr. 18, 1889
*MEADOWS, JAMES O. San. Engr., 1200 Papineau Ave., Montreal, Canada.......... June 21, 1920
MEERBURG, DR. P. A. Central Laboratories, Sterrebosch 1, Utrecht, Holland.......... Feb. 16, 1924
MEES, ERICH A. Consulting Engineer, Kinney Bldg., Charlotte, N. C.......... May 23, 1923
MEGRAW, WILLIAM A. 308 St. Dunstan's Road, Homeland, Baltimore, Md.......... Apr. 24, 1921
MEINECKE, H. Aktiengesellschaft, Breslau-Carlowitz, Germany.......... Sept. 17, 1924
*MELLEN, ARTHUR F. Filtr. Engr., Columbia Heights Filter Plant, Minneapolis, Minn.......... Mar. 24, 1915
MELLON, T. A. Pres. Kensington Water Co., 2112 Oliver Bldg., P. O. Box 1114, Pittsburgh, Pa.......... June 24, 1903
*MENDELSOHN, ISADOR W. U. S. Public Health Service, 45 Broadway, Room 502, New York, N. Y.......... Feb. 9, 1920

*MENOLD, HARRY. Supt., Water & Elec. Light Plant, Hinsdale, Ill........ May 24, 1927
*MENTZ, HENRY A. Cons. Engr., Lock Drawer No. 929, Hammond, La........ Oct. 7, 1919
*MERCKEL, FREDERICK G. Wallace & Tiernan Co., 180 N. Market St., Chicago, Ill........ Jan. 29, 1921
*MERRILL, GEORGE FIELD, C.E. Supt. Water Works, Ware, Mass........ Apr. 16, 1920
MERRIMAN, THADDEUS. Chf. Engr. Board of Water Supply, 2224 Municipal Bldg., New York, N. Y........ May 29, 1920
*MESSER, RICHARD. San. Engr., State Dept. of Health, 615 State Office Building, Richmond, Va........ Sept. 27, 1911
METCALFE, JAMES VIVIAN. Borough Water Engineer, Old Court House, Durban, South Africa........ May 11, 1928
*MEYER, H. R. J. 4551 Alice Avenue, St. Louis, Mo........ Jan. 19, 1925
MEYERHERM, CHARLES F. Albert F. Ganz, Inc., 511 Fifth Ave., New York, N. Y........ Jan. 26. 1922
MEYERS, A. H. Supt., Water Co., Columbia, Pa........ June 14, 1903
MEYERS, DUDLEY C. Comr. Public Works & Supt. Water Dept., Municipal Bldg., Oak Park, Ill........ Apr. 9, 1925
MICHAEL, A. M. Superintendent of Water Wks., Mebane, N. C........ Aug. 28, 1926
MICHAELS, A. P. Gen. Mgr., Orlando Utilities Comn., Orlando, Fla........ Aug. 15, 1924
*MICHAU, R. Chief Engineer, Water Works, French Concession, c/o French Tramways Co. 227 Avenue Dubail, Shanghai, China........ Mar. 3, 1927
MICHIE, JOHN C., C.E. Supt., Water Works Dept., Durham, N. C........ June 24, 1903
*MICKEL, CLARENCE W. Chemist, Muscle Shoals, Ala........ Aug. 8, 1922
MILES, H. B. 712 Washington St., Utica, N. Y........ June 30, 1924
MILHOLLAND, H. CHARLES. Asst. Engr. Am. W. W. & E. Co., 50 Broad St., New York, N. Y........ Apr. 20, 1923
*MILLER, ARTHUR P. Associate Sanitary Engineer, "C" Bldg., 16 Seventh St., S.W., Washington, D. C........ Sept. 25, 1920
MILLER, CHARLES F. 73 Vermont St., Rochester, N. Y........ Apr. 10, 1926
MILLER, CLIFFORD N. Hyd. Engr., 2807 Union Central Bldg., Cincinnati, Ohio........ May 13, 1915
MILLER, E. C. Asst. Engr., Penn. Dept. of Health, 5419 Germantown Ave., Philadelphia, Pa........ July 9, 1928
MILLER, EDWIN E. 1017 Edgewood Lane, Palisade, N. J........ Mar. 11, 1914
*MILLER, H. E. Director Bur. San. Eng., State Bd. of Hlth., Raleigh, N. C........ May 23, 1921
MILLER, H. I. Vice-Pres., Pacific Water Works Supply Co., Atlantic St. Terminal, Pier "A," Seattle, Wash........ Jan. 17, 1928
MILLER, J. A. Supt. Water Works, 10 West 3rd St., Alton, Ill........ May 8, 1909
*MILLER, MAURICE L. Hydraulic & Sanitary Engineer, P. O. Box 387, Waukegan, Ill........ Feb. 15, 1926
*MILLER, WARREN C. City Engr., City Hall, St. Thomas, Ont,, Can........ Feb. 28, 1923
*MILNE, ALEXANDER. Supt. Water Works, St. Catharines, Ontario, Canada........ June 24, 1903
*MINOR, EDWARD EASTMAN. Gen. Mgr. New Haven Water Co., New Haven, Conn........ May 20, 1912
*MINOR, L. O. Supt., Water Works, Plattsmouth, Nebr........ July 8, 1922
MITCHELL, J. J. 450 W. Grand St., Elizabeth, N. J........ Oct. 21, 1920
*MITCHELL, LEWIS. City Waterworks Engineer, Town Hall, Bradford, England........ Nov. 15, 1924

MIXSON, J. P. Superintendent Water Works, Palmetto, Fla... Dec. 22, 1926
*MOAT, CHARLES P. Chemist, Vermont State Board of Health, 2 Colchester Ave., Burlington, Vt.... Jan. 29, 1915
*MOBERG, A. R. 4044 Lyndale Ave., So., Minneapolis, Minn. Dec. 7, 1926
*MOHLMAN, FLOYD W. Chf. Chst., San. Dst. of Chicago, 1014 South Michigan Ave., Chicago, Ill.... Oct. 22, 1921
*MOHR, JACK. Superintendent Water Dept., 549½ So. Rugby Ave., Huntington Park, Calif.... June 5, 1926
MOIR, DONALD. Cia Aguas Corrientes, Calle Salta 1461, Rosario de Santa Fe, A. R.... June 25, 1924
*MOLIS, WM. Supt. Water Works, Muscatine, Iowa.... Mar. 15, 1882
*MONFORT, WILSON F. 215 Wall Bldg., Olive at Vandeventer, St. Louis, Mo.... July 10, 1906
MONROE, H. L. Supt. Water Works, Pontiac, Mich.... July 10, 1919
MONTABONE, A. J. F. Imperial Theater Bldg., Room 2, Montreal, Canada.... Nov. 9, 1922
*MONTANK, IRWIN A. Water Bacteriologist & Chemist, 500 Delaware St., S.E., Apt. 207, Minneapolis, Minn.... Jan. 24, 1928
*MONTGOMERY, JAMES M. Mgr., Municipal Water Works, City Hall, Piqua, Ohio.... June 6, 1927
MONTOULIEU, HENRY J., C.E. Calle B, No. 70, Entre 21 y 23, Vedado, Habana, Cuba.... Nov. 17, 1911
MOORE, CHARLES E. 311 Avenham Ave., Roanoke, Va.... Oct. 5, 1923
MOORE, CHARLES HERBERT. Messrs. Pearse, Greeley & Hansen, 6 No. Michigan Ave., Chicago, Ill.... July 9, 1928
*MOORE, GEORGE S. Superintendent Water & Light, Albemarle, N. C.... Apr. 23, 1924
*MOORE, J. W. Cons. Engr., 836 Ind. Pythian Bldg., Indianapolis, Ind.... Feb. 9, 1925
MOORE, R. M. Secty. & Mgr., Peoples Water Co., of Palms, Calif., 1018 Trust & Savings Bldg., Los Angeles, Calif.. June 30, 1920
*MOORE, RUSSELL B. Consulting Engineer, 930 K. of P. Bldg., Mass. and Penn. Sts., Indianapolis, Ind.... Feb. 3, 1928
*MOREHOUSE, WALLACE W. Director, Dept. of Water, Room 308, U. B. Annex, Dayton, Ohio.... Jan. 16, 1923
*MOREY, DAVID, JR. San. Engr., 517 Praetorian Bldg., Dallas, Texas.... May 21, 1923
*MORGAN, FRANK LESLIE. "Ribbesford," Styvechale Ave., Coventry, England.... June 30, 1926
MORGAN, HENRY B. Grand View Drive, Peoria, Ill.... Apr. 24, 1910
MORLAN, WILBERT. 58 S. Cottage St., Valley Stream, N. Y. May 24, 1922
*MORRILL, ARTHUR B. Asst. Engr. of Filtration, Dept. of Water Supply, 8100 W. Warren Ave., Detroit, Mich.... Oct. 21, 1925
MORRIS, CHARLES H. Supervisor of Water Works, New Brunswick, N. J.... June 7, 1916
*MORRIS, EDWARD. Vice President & Manager, Willets Water Company, Willets, Calif.... May 28, 1926
*MORRIS, FRED R. Sect., Appleton Water Commission, City Hall, Appleton, Wis.... Jan. 21, 1927
*MORRIS, SAMUEL BROOKS. Chf. Engr., Water Dept., 319 City Hall, Civic Center, Pasadena, Calif.... June 10, 1920
MORROW, BEN. S. Engineer, Water Bureau, 211 City Hall, Portland, Ore.... Apr. 13, 1926
MORSE, HOWARD SCOTT. Gen. Mgr., Indianapolis Water Company, 113 Monument Circle, Indianapolis, Ind.... Sept. 18, 1925
*MORSE, ROBERT B. Chf. Engr., Wash. Sub. San. Dist., Hyattsville, Md.... Mar. 11, 1915
MOSELEY, ALEX W., M.E. Sloan Valve Co., 4300 W. Lake St., Chicago, Ill.... Oct. 11, 1923

*MOSES, HOWARD E. Asst. Chf. Engr., Pa. Dept. of Health, 904 N. 2nd St., Harrisburg, Pa........................ Apr. 27, 1922
MOULLET, LOUIS F. Assistant Office Engineer, East Bay Water Company, 2212 Blake St., Berkeley, Calif........ May 28, 1926
*MOWREY, J. HASE. Manager of Public Utilities, 202 So. Second St., Chambersburg, Pa........................ July 20, 1925
*MUDGE, JOHN REXFORD. 414 Arroyo Drive, So. Pasadena, Calif.. May 27, 1924
*MUEGGE, O. J. 109 West Johnson Street, Madison, Wis.... May 20, 1925
MUELLER, CARL. Asst. Engr. Bureau of Water, 147 Pomona Ave., Newark, N. J.................................. Apr. 25, 1923
MULLERGREN, ARTHUR L. Cons. Engr., 770 Board of Trade Bldg., Kansas City, Mo.............................. Oct. 21, 1919
*MULLIGAN, D. G. Mountain States Inspect. Bur., P. O. Box 1740, Denver, Colo.................................. Mar. 26, 1928
MULLIKIN, ALFRED, C.E. Town Engineer, Northeast Harbor, Me.. Jan. 7, 1924
MUNDY, AMBROSE. Supt. Middlesex Water Co., Woodbridge, N. J.. Mar. 11, 1914
MUNN, HARVEY T. Hyd. Engr., Natl. Board of Fire Underwriters, 222 W. Adams St., Suite 953, Chicago, Ill..... Mar. 9, 1920
MUNROE, WALTER C. Savings Bank Bldg., Annapolis, Md... Jan. 30, 1924
*MURPHY, A. R., C.E. Fountain City, Tenn................ Apr. 7, 1911
*MURPHY, LINDON J. Engineering Extension Dept., Iowa State College, Ames, Iowa.............................. Jan. 10, 1927
*MURRAY, R. M. Hydraulic & Structural Engr., 1002-A Porter Bldg., Portland, Ore................................ Feb. 11, 1922
MURRIN, JOHN A. Supt. Water Works, City Hall, Rock Island, Ill... June 5, 1916
*MUSER, E. FRED. Supt. Clear Springs Water Co., P. O. Bldg., Catasauqua, Pa.............................. Dec. 22, 1920
*MUSSER, H. P. Kanawha National Bank Bldg., Charleston, W. Va.. Oct. 31, 1922
*MYERS, ROBERT HARRISON. Pub. Util. Mgr., Stratford, Ont. Feb. 10, 1921
MYERS, WARREN G. Sales Engineer, 133 Brevard Court, Charlotte, N. C...................................... Oct. 18, 1927
MYRTUE, JOHN J. Water Works Trustee, 615 S. 7th St., Council Bluffs, Iowa.................................. Feb. 27, 1924

NAUMANN, H. T. G. City Chemist, 1024 8th St., Port Huron, Mich.. Apr. 3, 1923
NEBELUNG, GEORGE H. Asst. Engr., Scranton Gas & Water Co., 813 Wheeler Ave., Scranton, Pa.................. Oct. 11, 1921
*NEGRI, MARIO L. Chf. Div. Engr., Obras Sanitarias de la Nacion, Rivadavia 2591, Buenos Aires, A. R........... Nov. 24, 1926
NELSON, FRED B., C.E. 950 Woodycrest Ave., Highbridge, N. Y.. July 18, 1907
*NELSON, GEO. A. Supt., Water Works, City Hall, Boone, Iowa.. June 6, 1927
*NELSON, GEORGE I. Wallace & Tiernan Co., 605 Star Bldg., St. Louis, Mo.................................. Mar. 21, 1923
NEVILLE, WILLIAM J. 1524 Candler Bldg., Atlanta, Ga..... Aug. 31, 1923
*NEVLING, J. B Secty.-Treas. Clearfield Water Co., Clearfield, Pa.. Oct. 16, 1914
NEWCOMB, J. P. Secretary, City Water Board, San Antonio, Texas.. Jan. 30, 1926

*NEWCOMER, FRANK. Senior Engineer, with Harry O. Garman, Consulting Engr., 27 Woodland Drive, Indianapolis, Ind. Dec. 15, 1925
NEWELL, CLARK. Supt. Water Works, Provo City, Utah. July 23, 1928
NEWKIRK, S. F., JR. Elizabethtown Water Co., Consol., 64 Broad St., Elizabeth, N. J. Oct. 18, 1927
*NEWLANDS, JAMES A. San. Engr., 11 Laurel St., Hartford, Conn. **Oct. 14, 1914**
NEWSOM, REEVES J. Vice Pres., Community Water Supply Co., 46 Cedar St., New York, N. Y. Nov. 18, 1918
NICHOLS, E. M., C.E. 27 N. 38th St., Philadelphia, Pa. June 16, 1919
NICHOLSON, ROBERT H. Consulting Engr., 1127 East 61st St., Los Angeles, Calif. May 17, 1927
NIESLEY, W. M. Asst. to Sect. A. W. W. A., 29 West 39th Street, New York, N. Y. Apr. 30, 1924
*NIMMO, JOHN P. Supt. Water Department, 617 N. Rodney St., Helena, Mont. July 13, 1927
NISHIOEDA, SATORU. 369 Nishiokubo, Suburb of Tokyo, Japan. Sept. 16, 1914
NOACK, ARTHUR. Consulting Municipal Engineer, 236 Main St., Hackensack, N. J. May 5, 1928
*NOBLE, RALPH E. Senior Bacteriologist, 1739 E. 67th St., Chicago, Ill. Mar. 22, 1927
*NOLTE, AUGUST G. Sanitary Engineer, 4204a Kossuth Ave., St. Louis, Mo. Dec. 30, 1916
*NORCOM, GEORGE D. Federal Water Service Corp., 27 William St., New York, N. Y. June 10, 1921
NORDMANN, CLARENCE F. 25 River St., Mamaroneck, N. Y. Feb. 7, 1927
NORMAN, EARL E. Supt. Dept. of Pub. Utilities, City Hall, Kalamazoo, Mich. Sept. 11, 1924
*NORRIS, JOHN ALEXANDER. Chairman State Bd. of Water Engrs., Capitol Sta., Austin, Tex. **June 16, 1919**
*NORRIS, M. ALVIN. Chemist, Orlando Utilities Comm., Orlando, Fla. Feb. 10, 1927
*NORTON, JOHN F. Dept. of Health Laboratories, Herman Kiefer Hospital, Detroit, Mich. May 25, 1926
NUEBLING, EDWARD. Asst. Engr., Dept. of Water Supply Gas & Elec., 1 Northern Avenue, New York, N. Y. Mar. 31, 1925
***NUEBLING, EMIL L. Cons. Engr., 519 Penn St., Reading, Pa. May 29, 1895**
***NUTT, J. A. Supt. Water Works, Monongahela, Pa. May 17, 1916**

OBERHOLTZER, D. A. Supt. Water Dept., 133 W. Garvey Ave., Monterey Park, Calif. May 17, 1927
*O'CONNOR, PHILLIP J. Supt. Filtration, 540 Kenilworth Rd., Warren, Ohio. Feb. 11, 1922
ODIET, J. E. Supt. Water Department, Ronan, Montana. June 8, 1925
***OHLIGER, L. B. Supt. Water Works, Canton, Ohio. Nov. 12, 1919**
O'LEARY, JOHN E. Pittsburgh-Des Moines Steel Co., 50 Church St., New York, N. Y. July 27, 1926
OLMSTEAD, CHARLES S. Supt., The Monterey Co. Water Works, Pacific Grove, Calif. Apr. 16, 1916
*OLSEN, WILLIAM C. Cons. Engineer, Box 1114, Raleigh, N. C. Dec. 12, 1921
*OLSON, W. M. Sanitary Engineer, 737 S. Lincoln St., Chicago, Ill. Apr. 10, 1926
O'NEALL, A. T. Supt. Water Works, Washington C. H., Ohio. Apr. 29, 1924
O'NEIL, PERRY. Contr. Engr., Municipal Engineering Co., 1107 Athletic Club Bldg., Dallas, Tex. Mar. 20, 1922

*O'NEILL, JOHN H. Louisiana State Bd. of Health, New Orleans, La. .... Apr. 27, 1925
*ORCHARD, WILLIAM J. Sanitary Engineer, P. O. Box 178, Newark, N. J. .... Aug. 16, 1917
*O'REILLY, A. R. 1337 Good Street, Reading, Penna. .... May 30, 1925
ORNSTEIN, DR. GEORG. Alexandrinen Str. 48, Berlin S. 14, Germany .... Jan. 12, 1928
*ORR, ALEXANDER, C.E. Chief Engineer, Gloversville Water Works, Gloversville, N. Y. .... Aug. 7, 1909
*ORR, C. A. Mgr., City Wtr. & Lt. Co., Mayfield, Ky. .... June 8, 1921
*ORTON, JAMES W. Engineering Office, Waterworks Park, Detroit, Mich. .... Mar. 6, 1926
ORUM, W. J., Vice-Pres. Commissioners of Water Works, City Hall, Montgomery, Ala. .... July 9, 1928
*OSBORNE, JAMES Q. Dist. Mgr., De Laval Steam Turbine Co., 1306 Smith Bldg., Seattle, Wash. .... Jan. 17, 1928
O'SHAUGHNESSY, M. M. City Engineer, 2732 Vallejo St., San Francisco, Calif. .... July 18, 1907
OUTZEN, ANDREW N. Field Engr., Detroit City Gas Co., Detroit, Mich. .... Aug. 1, 1923
*OVERSTREET, RALPH M. Supt., Henderson Water Works, 932 N. Main St., Henderson, Ky. .... Jan. 6, 1927
*OWENS, ROBERTS B., B.A., B.E. Government Bdgs., Edmonton, Alberta, Canada .... Apr. 27, 1914
OWINGS, NOBLE L. Asst. Engr. Washington Suburban San. Dist. Riverdale, Maryland .... Jan. 4, 1923

PAIN, HERBERT. Managing Dir., Phillips & Pain, Water Sftg., 1 Rue Taitbout, Paris, France .... Mar. 27, 1925
PAINTER, CARL ELLICOTT. V. P. & Cons. Engr., Water Works Equipment Co., Salt Lake City, Utah .... Mar. 25, 1924
PAITOVI, ANTONIO, C.E. Rivadavia 13353, Ramos Mejia-F C. O., Buenos Aires, A. R. .... July 27, 1919
PALMER, MARSHALL B. Engr. Bureau of Water, Syracuse, N. Y. .... May 24, 1922
*PALMER, RAY S. Water Works Superintendent, Le Roy, N. Y. .. Mar. 6, 1926
PALMER, RUSSELL R. Editor, "Western Waterworks," 819 Santee St., Los Angeles, Calif. .... Sept. 18, 1926
PARKER, E. F. C. Comptroller, Federal Water Service Corp., 27 William St., New York, N. Y. .... Sept. 13, 1928
*PARKER, FRANCIS L. Ph.D., M.D., Parker Laboratory, 40 Broad St., Charleston, S. C. .... Jan. 31, 1925
*PARKER, G. H. Mgr., Kentucky Actuarial Bureau, 303 Speed Bldg., Louisville, Ky. .... Feb. 23, 1924
*PARKER, HORATIO NEWTON. City Bact. & Chst., Main & Orange Sts., Jacksonville, Fla. .... June 16, 1920
PARRISH, C. A. Supt. & Manager Water Dept., Compton, Calif. .... July 23, 1923
PARSONS, CHARLES W. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill. .... Apr. 2, 1923
*PARSONS, L. C. Supt. Municipal Water & Lt. System, Box 636, Kings Mountain, N. C. .... July 30, 1926
*PARTRIDGE, E. M. Chf. Chemist, Paige & Jones Chemical Co., Hammond. Ind. .... Feb. 20, 1925
*PASSOLT, A. A. Supt., Newnan Water & Light Commission, Newnan, Georgia .... May 12, 1925
PATE, R. L. Manager City Water Co., Springfield, Mo. .... June 29, 1915
*PATERSON, WILLIAM. Windsor House, Kingsway, London, England .... Nov. 6, 1924

*PATITZ, G. J. 701 Washington St., New York, N. Y. .... Oct. 24, 1923
*PATTERSON, RICHARD L. City Engr., and Supt. of Water Dept., Newport Beach, Calif. .... Sept. 21, 1928
*PATTERSON, T. C. Superintendent Water Works, Mt. Holly, N. C. .... Dec. 8, 1923
*PATTON, W. A. Pres. & Mgr. Water Co., Catlettsburg, Ky. .... June 7, 1904
PATTON, W. S. Mgr. Ashland Water Works, Ashland, Ky. .... May 7, 1917
PAUL, FRANK DWIGHT. Superintendent of Distribution, Akron City Water Works, 235 Crescent Drive, Akron, Ohio .... Jan. 21, 1927
PAUL, MARCEL. President, Societe Anonyme des Hauts-Fourneaux & Fonderies de Pont-a-Mousson 9-13 Rue St. Leon, Nancy, France .... Feb. 18, 1927
*PAULETTE, G. W. 4929 Walrond St., Kansas City, Mo. .... Feb. 18, 1927
PAULETTE, R. J. City Engineer, City Bldg., Salina, Kansas .... Feb. 17, 1927
PEABODY, J. R., M.D. 456 Francis Bldg., Louisville, Ky. .... Dec. 29, 1924
*PEARSE, LANGDON. San. Engr., The Sanitary Dist. of Chicago, S. O. Bldg., 910 S. Michigan Ave., Chicago, Ill. .... Feb. 24, 1913
*PEARSON, CHARLES DEARNE. Engr. & Mgr., Wtr. Wks., Kiangse Rd., Shanghai, China .... Mar. 16, 1922
PEART, JOHN. Water Supply Engineer, Metropolitan W. S. & S. Board, Brisbane, Queensland .... Sept. 12, 1910
*PEASE, HERBERT D. 39 W. 38th St., New York, N. Y. .... Feb. 6, 1924
PECK, ERMON M. Cons. Engr., 260 Edgewood St., Hartford, Conn. .... July 18, 1907
PECK, LAWRENCE J. District Engineer, 91 Prospect Street, Cortland, N. Y. .... May 17, 1927
*PEDERSON, H. V. Superintendent Water Works, Municipal Bldg., Marshalltown, Iowa .... Mar. 26, 1922
*PIERCE, WALTER A. Manager, Racine Water Dept., 2217 Taylor Ave., Racine, Wis. .... June 15, 1922
PEIRSON, A. G. Supt., Water Power & Light Commission, Weston, Ont., Canada .... Feb. 28, 1923
*PENDER, L. E. Supt. Construction & Pub. Utilities, Pinehurst N. C. .... Apr. 23, 1924
PEQUEGNAT, MARCEL, B. A. Sc. Supt. Kitchener Water Comm. Kitchener, Ont. .... Feb. 16, 1924
PERHAB, JOHN L. Superintendent Water Dept., P. O. Box 1333, Calexico, Calif. .... May 29, 1926
PERKINS, C. E. Supt. of Waterworks, Bartlesville Water Co., Bartlesville, Okla. .... Feb. 14, 1928
*PERKINS, DR. R. G. Dept. of Hygiene, W. R. U. School of Medicine, 2109 Adelbert Road, Cleveland, Ohio .... June 3, 1921
PERRY, H. W. Supt., Water Works, Box 647, Greenville, S. C. .... Apr. 25, 1922
PERRY, J. ROBERT. Accountant, Municipal Water Dept., Walnut Ave., & 6th St., Niagara Falls, N. Y. .... June 20, 1924
PERRY, V. E. Manager, Water Sales Dept., Spring Valley Water Co., 425 Mason St., San Francisco, Calif. .... Apr. 16, 1928
*PERRY, WILLIAM. Hydraulic Engr., Maplewood Ave., Cote des Neiges, Montreal, Quebec .... June 26, 1886
PETERS, H. D. Assistant Engineer, State Board of Health, Jefferson City, Mo. .... June 1, 1928
*PETERS, J. S. Chf. Engr., Marin Municipal Water Dist., San Rafael, California .... Jan. 6, 1927
PETERSEN, C. O. Water Superintendent, City Hall, Brighton, Colo. .... Mar. 27, 1926

PETERSON, LEONARD. Supt. Water Works, Power & Light Co., Crookston, Minn. ... June 10, 1911
*PHARAOH, HARRY W. Supt. Citizens Water Co., 207 Spruce St., Philipsburg, Pa. ... Dec. 8, 1927
*PHELPS, EARLE B. Prof. Sanitary Science, Columbia University, 437 West 59th St., New York, N. Y. ... Oct. 19, 1914
PHILLIPS, ASA E. Box 234, Ogunquit, Maine ... Nov. 9, 1922
PHILLIPS, CHARLES J. Water Supt. & City Engr., City Hall, Puyallup, Wash. ... Sept. 13, 1927
*PHILLIPS, LEO A. Chf. Engr., Federal Water Service Corp., 27 William St., New York, N. Y. ... June 17, 1926
PIATT, WILLIAM M. Cons. Engr., Durham, N. C. ... Aug. 5, 1921
*PIERCE, J. F. Springdale, Pa. ... Feb. 16, 1924
PIERCE, THOMAS D. Appraisal & Rate Engineer, 324 No. Drexel Ave., Columbus, Ohio ... May 12, 1925
*PILGRIM, HENRY E. A. Supt., Water Works, 160 College St., St. James, Man., Canada ... June 1, 1927
*PINCUS, SOL. San. Engr., 309 West 109th St., New York, N. Y. ... Feb. 17, 1920
PINNELL, DR. W. R. City Bacteriologist, Lexington, Ky ... June 1, 1923
*PIPPIN, R. E. Water Supt., Zebulon, N. C. ... Sept. 10, 1928
*PIRNIE, MALCOLM. Consulting Engineer, 25 W. 43rd St., New York, N. Y. ... May 8, 1917
*PITCHER, F. H. G. Mgr. & Ch. Engr., Montreal W. & P. Co., Place D'Armes Square, Montreal, Canada ... June 27, 1905
*PLAMONDON, ADRIEN, C.E. Engineer & Contractor, 70 St. James St., Montreal. Canada ... May 22, 1916
PLOCH, C. E. Supt., Mt. Vernon Water Works Co., 127 Main Street, Mt. Vernon, Ind. ... Jan. 27, 1925
PLUMMER, WADE. Asst. Supt., Butte Water Co., Butte, Mont. Dec. 15, 1925
*POE, CHARLES F. 875—16th St., Boulder, Colo. ... Sept. 24, 1926
POLGLAZE, R. A. Pres., Warrior Water Co., American-Traders Bldg., Birmingham, Ala. ... May 25, 1926
*POLK, WESLEY W. Supt., Water Department, Sheridan Rd. & Lincoln St., Evanston, Ill. ... Mar. 10, 1926
*PORT, JOHN A. Supt. Van Gilder Water Meter Co., 518 Bridgeboro St., Riverside, N. J. ... May 28, 1924
*PORTER, D. P. Supt. Water Works, 1305 E. 4th St., Pueblo, Colo ... Sept. 22, 1916
PORTER, JOHN LEWIS. Director, Water Purification Stations, 2142 Eagle Street, New Orleans, La. ... May 12, 1925
PORTER, S. J. 345 Vermont St., San Francisco, Calif. ... Oct. 27, 1925
*PORZELIUS, A. F. Supt. City Water Co., Chattanooga, Tenn. July 7, 1920
*POTTER, ALEXANDER. Consulting Engineer, 50 Church St., New York, N. Y. ... July 18, 1907
*POTTER, HOWARD P. Cons. Civil & Sanitary Engineer, 36 North Side Square, Jacksonville, Ill. ... Mar. 19, 1928
*POTTS, CLYDE. Civil & Sanitary Engr., 30 Church St., New York, N. Y. ... July 10, 1906
POWELL, ALEXANDER C. 136 Grant Street, Bangor, Me. ... Mar. 12, 1910
*POWELL, SHEPPARD T. Chemical Engineer, 4103 Hawthorne Ave., Forest Park, Baltimore, Md. ... July 10, 1906
*PRACY, GEO. WESLEY. Supt. Spring Valley Water Co., 425 Mason St., San Francisco, Calif. ... May 18, 1915
*PRATT, ARTHUR H. Chf. Engr., North Jersey Dist. Wtr. Supply Comn. 20 Clinton Street, Newark, N. J. ... Jan. 4, 1923
PRATT, CHARLES J. Supt. Water Department, City Hall, Owen Sound, Ont., Canada ... Oct. 22, 1924

*PRATT, GILBERT H. P. O. Box 178, Newark, N. J. .... June 5, 1916
*PRATT, ROGER W. Wallace & Tiernan Co., Inc., 223 E. 9th St., Kansas City, Mo. .... Feb. 13, 1924
*PRAY, JOHN W. Supt. Water Works, Ft. Dodge, Ia. .... June 24, 1913
PRENTICE, E. R. Secretary, Marin Municipal Water Dist., 468—4th St., San Rafael, Calif. .... June 29, 1928
*PRINCE, NORMAN F. Chemist & Engineer, Rochester Gas & Elec. Corp., Rochester, N. Y. .... Mar. 26, 1927
PRINDLE, GEORGE B. c/o Pearse, Greeley & Hansen, 6 North Michigan Ave., Chicago, Ill. .... Mar. 25, 1924
*PRINGLE, D. RHETT. Supt. of Water & Light Dept., Thomasville, Ga. .... Sept. 27, 1924
PRINGLE, J. T. Supt. Stamford Water Works, Stamford Township, South end, Ont., Canada .... Apr. 28, 1925
*PRINZ, ROBERT B. Asst. Engr., Dept. of Water, Room 308, U. B. Annex, Dayton, Ohio .... Sept. 7, 1927
PRIOR, J. MURRAY. Board of Water Supply, Room 710, 100 State St., Albany, N. Y. .... Apr. 10, 1924
*PRIOR, JOHN C. Prof. of Sanitary Engineering, Brown Hall, Ohio State Univ., Columbus, Ohio .... Oct. 13, 1926
*PRITCHARD, JOHN C. Director of Public Utilities, 312 City Hall, St. Louis, Mo. .... Feb. 8, 1926
PROBST, RUDOLPH. Superintendent Butte Water Co., Butte, Mont .... Dec. 15, 1925
PROCTOR, EDWARD M. Cons. Engr., 177 Inglewood Drive, Toronto 5, Ont., Canada .... May 5, 1921
PROKOFIEFF, S. T. Executive Engineer, Drainage & Water Works, Gwalior, India .... Oct. 27, 1922
*PROVOST, ANDREW J., JR. San. Expert & Hyd. Eng., 39-41 West 38th St., New York City .... May 12, 1908
PRUETT, G. C., C.E. Virginia, Minn. .... Feb. 2, 1914
*PRUGH, J. I. Supt. Division of Water, City Hall, Sacramento, Calif. .... Nov. 8, 1923
PUGH, MARSHALL R., C.E. 230 Poplar Ave., Wayne, Pa. .... Apr. 8, 1905
PURCELL, HUGH G. Manager, Hugh G. Purcell Company, 304 Colman Bldg., Seattle, Wash. .... Jan. 30, 1928
PURKYNE, DR. EMANUEL. Officer State Board of Health, Statni Zdravotni Ustav CSR., Prague XII, Czechoslovakia .... July 19, 1928
PUTNAM, EBEN F. Pres., Greenwich Water Co., 253 Greenwich Ave., Greenwich, Conn. .... Dec. 8, 1927
*PUTNAM, GEORGE W. 7110 Oriole Ave., Chicago, Ill. .... June 15, 1922

QUAYLE, LEROY A. Chf. Mech. Engr., Utilities Dept., 1440 W. 98th St., Cleveland, Ohio .... Feb. 24, 1925
*QUIGLEY, LEWIS A. Supt., City Water Works, 2626 Travis, Fort Worth, Texas .... June 6, 1927
*QUINNELL, FRED. Comnr. Public Works, Bx. 684, Roundup, Mont .... Feb. 7, 1922

*RAAB, FRANK. Chst. & Bact. Fridley Filtration Plant, Minneapolis, Minn. .... Oct. 26, 1921
*RACE, JOSEPH. Devonshire Hospital, Buxton, England .... May 18, 1914
*RADCLIFFE, JOHN L. Supt. Filtn., 535 Trotter Lane, Elizabeth, N. J. .... Feb. 19, 1920
RADER, R. P. Sup., Lehigh Water Co., Easton, Pa. .... May 12, 1908
*RAINEY, CLARENCE M. Water Superintendent, 735 W. Bonneville St., Pocatello, Idaho .... Nov. 15, 1927

Ramey, H. P. Asst. Chf. Engr., Sanitary District of Chicago, 910 So. Michigan Ave., Chicago, Ill.	June 6, 1927
Randlett, Fred Morse. Robert W. Hunt Co., 251 Kearny St., San Francisco, Calif.	June 16, 1920
Randolph, Bud A. City Health Department, Houston, Tex.	Mar. 13, 1925
*Rasch, Henry B., Jr. 4510 Woodlawn Ave., Chicago, Ill.	Nov. 29, 1926
*Rassier, Christian C. Supt., Water Works, 330 W. Coal St., Shenandoah, Pa.	May 24, 1922
*Rathbun, W. S. Natl. Bd. of Fire Underwriters, 222 W. Adams St., Room 953, Chicago, Ill.	Apr. 13, 1922
*Ray, Chas. E., Jr. Asst. Engr., Dept. of Conservation & Development Water Resources Division, Chapel Hill, N. C.	Aug. 28, 1926
*Raymond, George B. Supt. Water Dept., Danbury, Conn.	June 16, 1919
*Reber, Harry C. Pres., Angelica Water & Ice Co., 1907 Perkiomen Ave., Reading, Pa.	Aug. 20, 1924
*Redfern, W. Blaine. Sec. Treas. James, Proctor & Redfern, Cons. Engs., 115 High Park Ave., Toronto, Ont.	Nov. 12, 1919
Reed, D. A. Mgr. Water and Light Dept., Duluth, Minn.	Sept. 20, 1913
*Reeder, Arthur L. Mahoning Valley San. Dist., 901-906 City Bank Bldg., Youngstown, Ohio	Nov. 30, 1926
*Reeves, O. Lee. Supt., Water Works Co., 26 South Jackson St., Greencastle, Ind.	May 24, 1922
*Reid, Walter. Supt., Water Works, Springfield, Ill.	May 24, 1922
Reilly, Thomas William. Supt., Pequannock Watershed, Charlotteburg, Passaic Co., N. J.	Mar. 17, 1925
*Reinhard, George C. Chemist, Feedwaters, Inc., 26 Cortlandt St., New York, N. Y.	Feb. 24, 1928
*Reinhardt, Harry. Asst. Chf. Engr., East Bay Water Co., Oakland, Cal.	Apr. 12, 1921
*Reinke, Edward A. 102 C. E. Bldg., Berkeley, California.	Nov. 8, 1923
Reisweber, Alex. G. Asst. Engr., Western New York Water Co., 11 Niagara St., Buffalo, N. Y.	Jan. 20, 1921
Relph, O. S. Superintendent Water Works, San Jose, Calif.	Oct. 27, 1925
Requardt, Gustav J., C.E. 18 E. Lexington St., Baltimore, Md.	May 17, 1923
*Reyer, George. Supt. Water Works, Nashville, Tenn.	Apr. 16, 1884
Reynolds, Edwin G., Jr., C.E. New Rochelle Water Co., 514 Main St., New Rochelle, N. Y.	Feb. 26, 1921
Reynolds, James H. Supt., Water Works, Lowell, Mass.	May 28, 1924
Reynolds, Myron B. Asst., City Engineer, 402 City Hall, Chicago, Ill.	Apr. 10, 1926
*Reynolds, Otto S. Water Works Engineer, 918 Armour Blvd., Kansas City, Mo.	Aug. 5, 1927
*Reynolds, Ralph W. Supt., West Palm Beach Water Co., Drawer B-25, West Palm Beach, Fla.	Nov. 15, 1926
*Rhoads, A. L. Supt., W. Va. Water Service Co., Bluefield, W. Va.	May 25, 1926
Rhodes, C. I. 820 Colusa Ave., Berkeley, Calif.	Oct. 22, 1924
Rhyne, C. E. Supt. Water Works, Gastonia, N. C.	Jan. 17, 1922
Rhynus, C. P. 122 East Par Ave., Orlando, Fla.	May 14, 1912
Rice, Clifton L. P. O. Box A 45,, West Palm Beach, Fla.	July 7, 1920
*Rice, Cyrus Wm. 617 Highland Bldg., Pittsburgh, Pa.	Oct. 5, 1924
*Rice, John M. Cons. Engr., 411 Oliver Bldg., Pittsburgh, Pa.	June 8, 1921
*Rice, P. D. Sweetwater, Water Corp., National City, Calif.	Nov. 15, 1926
Richardson, Charles G. Sales Mgr., c/o Builders Iron Foundry, Providence, R. I.	July 7, 1920
*Richardson, H. H. 3219 West 62nd Place, Chicago, Ill.	Aug. 23, 1920

*Rickard, Grover E. Chemist & Supt. of Filtration, 1909 Warwood Ave., Wheeling, W. Va. June 5, 1926
*Rider, Jane H. Dctr. Ariz. State Laboratory, Tucson, Ariz. Aug. 23, 1920
*Ridley, Clarence Eugene. 261 Broadway, New York, N. Y. Dec. 5, 1918
Riebel, Thomas S. Supt. Queen Lane Filters, 942 E. Price St., Philadelphia, Pa. May 28, 1924
Riffee, George A. Supt. Shinnston Water Board, Shinnston, W. Va. Jan. 30, 1924
Riley, Chas. R. Asst. Supt. Norwich Water Works, 7 Northrup Ave., Norwich, N. Y. June 17, 1926
*Ringness, Henry. Supt. of Accts., Peoria Water Works Co., 105 N. Monroe St., Peoria, Ill. Sept. 8, 1919
*Ristine, G. W., Jr. Secy. & Treas., Shankland, Ristine & Co., 410 Boston Bldg., Denver, Colo. May 12, 1925
Ritchie, Edgar Gowar. Engineer of Water Supply, Metropolitan Board of Works, Melbourne, Australia. Sept. 6, 1912
*Roads, George M., Jr. Supt., Panther Valley Water Co., Edgemont, Lansford, Pa. Oct. 22, 1926
Robbins, W. D. City Mgr., City Hall, Niagara Falls, N. Y. Feb. 23, 1926
Roberts, Alfred M. V. P. & Mgr., Wanakoh Water Co., 259 Delaware Ave., Buffalo, N. Y. July 20, 1925
Roberts, Earl I. 1601 Second National Bank Bldg., Toledo, Ohio. Jan. 11, 1918
Roberts, John S., Jr. Borough Engr., Bristol, Pa. June 19, 1920
*Roberts, William J. Cons. Engr., 616 Puget Sound Bank Bldg., Tacoma, Wash. Oct. 19, 1914
*Robertson, George Cook. Sanitary Engineer, 760 Avenida de Mayo, Buenos Aires, Argentina. Jan. 6, 1928
*Robertson, John T. Engr., Consolidated Water Co., 712 Washington St., Utica, N. Y. Mar. 26, 1927
Robinson, Delbert W. General Foreman, Water Co., Box 3113, West Palm Beach, Fla. Apr. 23, 1927
Robinson, J. W. Genl. Mgr., Pico County Water District, P. O. Box 639, Pico, Calif. June 11, 1928
Robinson, Leonard C. Supt. Water and Sewer Dept., Concord, Mass. July 18, 1907
Robinson, William P. 1700 East 3rd Ave., Denver, Colo. June 8, 1897
Robles, Gonzalo. Gerente, Torreon Water Works, Rodriguez Sur 10, Torreon, Coah, Mexico. June 6, 1927
*Rockwell, Willard F. Consulting Engineer, 400 No. Lexington Ave., Pittsburgh, Pa. Feb. 14, 1928
*Roen, O. S. City Manager, South Pasadena, Calif. Oct. 18, 1923
*Rogers, M. W. Engineer, Public Utility Commission, Box 413, Carleton Place, Ont., Canada. Mar. 16, 1927
*Rogers, T. M. Supt., City Water & Light Plant, Easley, S. C. May 31, 1927
Rohrbach, Wm. R. Mgr. Sunbury Water Co., Sunbury, Pa. July 10, 1906
Romig, C. O. Secty. and Supt. Water Supply Co., Dennison, O. Oct. 23, 1917
*Roos, Charles M. Secty. and Supt. Cairo Water Co., Cairo, Ill. May 18, 1913
*Roper, Roswell M. Engr., Bd. of Water Comnrs., East Orange, N. J. May 10, 1919
Rosenthal, Helman 2411 S. Harwood Street, Dallas, Tex. June 3, 1918
Rosentreter, Herman. Engr. of Water Supply, City Hall, Newark, N. J. Mar. 12, 1908
*Roskelley, C. O. Civil Engineer, Brigham City, Utah. Feb. 20, 1924
Rossman, John D. 15800 Halsted Street, Harvey, Ill. June 6, 1927

Routh, James W. Bureau of Municipal Research, Athletic Club Building, St. Paul, Minn.	June 4, 1920
Routledge, George Graham. Supt. Water Distb. Section, 332 St. Clair Ave., E., Toronto, Ont.	Mar. 18, 1919
Rowe, E. A. 543 Petroleum Securities Bldg., 714 W. 10th St., Los Angeles, Calif.	Nov. 9, 1922
***Rowe, E. J.** Supt. Water & Light Dept., Wellsville, N. Y.	June 3, 1921
Rowe, Llewellyn H. Water Works Engineer, Box 123, Opa Locka, Fla.	Apr. 23, 1927
*Ruchhoft, C. C. 1014 S. Michigan Ave., Chicago, Ill.	June 16, 1925
Rudd, William C. Dept. of Water Supply, Div. of Eng., 8100 W. Warren Ave., Detroit, Mich.	June 14, 1923
Rudderow, Maurice B. Mgr. Merchantville-Pensauken Water Co., 13 W. Maple Ave., Merchantville, N. J.	June 23, 1914
Rue, J. A. Water Engr., Cent. Ill. Pub. Service Co., 1217 Marshall Ave., Mattoon, Ill.	Apr. 7, 1916
Ruggles, A. V. Asst. to Sect., American Water Works Assoc., 29 W. 39th St., New York, N. Y.	Aug. 16, 1920
*Rupp, Daniel H. Water Department, City Hall, Oklahoma City, Okla.	Oct. 14, 1922
Russell, Alexander. Sect. & Treas., Rochester & Lake Ontario Water Co., 440 Powers Bldg., Rochester, N. Y.	Sept. 21, 1927
***Russell, Brinton.** Supt. Water Co., Norristown, Pa.	May 23, 1923
Russell, Charles S. Chf. Engr., Opa Locks Co., Inc., Box 1, Opa Locka, Fla.	Apr. 23, 1927
***Russell, D. A.** Chief Chemist, Youngstown Sheet & Tube Co., Youngstown, Ohio	May 31, 1924
Russell, Norman F. S. Drawer 306, Burlington, N. J.	Dec. 10, 1915
Ruth, Edward D. Supt., Water Dept., City Hall, Lancaster, Pa.	May 1, 1922
Ryle, John. Asst. Supt., Passaic Consolidated Water Co., 158 Ellison St., Paterson, N. J.	Dec. 3, 1919
*Sabin, M. S. Asst. Sanitary Engineer, State Dept. of Public Health, Springfield, Ill.	Apr. 6, 1928
***Sackett, Robert L.** Dean, School of Engineering, Pa. State College, State College, Pa.	Nov. 21, 1912
Saenz, Samuel. Civil Engineer, Heredia, Costa Rica, C. A.	June 5, 1928
***Safford, Arthur T.** Engr., Proprietors Locks & Canals, 66 Broadway, Lowell, Mass.	Feb. 4, 1921
Salisbury, J. W. Civil Engineer, Chinchilla, Lackawanna Co., Pa.	June 13, 1924
Salmond, James J. Manager *Canadian Engineer*, 62 Church St., Toronto, Ont., Can.	July 18, 1907
*Sample, J. D. Vice Pres., McWane Cast Iron Pipe Co., Birmingham, Ala.	Feb. 26, 1926
Samuel, T. D., Jr. Chief Engr. and Supt., Water Dept., City Hall, Kansas City, Mo.	Oct. 5, 1928
*Sanborn, James F. Consulting Engineer, 30 Church St., Rm. 414, New York, N. Y.	Aug. 22, 1921
***Sanderson, A. U.** Supt. Toronto Filtn. Plant, Foot of John St., Toronto, Canada	June 9, 1920
*Sandquist, Emil. City Engineer, Havre, Mont.	Jan. 17, 1927
Saunders, Wm. E., E.M. Librarian, United Gas Improvement Co., Broad & Arch Sts., Philadelphia, Pa.	July 26, 1919
*Saurbrey, Kay N. G. 109 E. Mary St., Valdosta, Ga.	June 28, 1926
***Saville, Caleb Mills.** Mgr. & Chf. Engr. Water Works, 53 North Beacon St., Hartford, Conn.	Mar. 18, 1916

*SAVILLE, THORNDIKE. Prof. of Hydrau. & San. Engr., Univ. of No. Carolina, and with Dept. of Conservation & Devel., Box 352, Chapel Hill, N. C. .... Aug. 30, 1920
*SAWIN, LUTHER R. Bacteriologist in Charge of Mt. Kisco Laboratory, Mt. Kisco, N. Y. .... July 14, 1916
SAYER, FRED D. Supt., Brookville Borough Water Dept., Brookville, Pa. .... Apr. 22, 1914
*SCARTH, STANILAND. Supt. of Water, Light & Power, Fairport, N. Y. .... Aug. 9, 1916
*SCHANTZ, P. T. Supt. Highland Water Works, Co., Highland, N. Y. .... May 25, 1926
SCHARFF, MAURICE R. Consulting Engineer, Farmers Bank Bldg., Pittsburgh, Pa. .... Jan. 1, 1926
*SCHAUT, GEORGE G. 925 W. Susquehanna Ave., Philadelphia, Pa. .... Oct. 23, 1922
*SCHEFFER, LOUIS K. Asst. Engr. San. Engineering, 1013 Green St., Harrisburg, Pa. .... Jan. 26, 1924
SCHERER, FREDERICK G. Asst. Engr. Bureau of Water, City Hall, Newark, N. J. .... Dec. 26, 1919
SCHIEDEL, C. W. Secy.-Treas. & Genl. Mgr. Water & Light Comn., Waterloo, Ont., Can. .... Apr. 26, 1921
SCHLICHT, JOHN C. Supt. of Pipe System, Hackensack Water Co., 624 Park Ave., Weehawken, N. J. .... June 15, 1926
*SCHMID, T., JR. Jr. Sanitary Engineer, 10856 Wabash Ave., Chicago, Ill. .... Apr. 16, 1926
*SCHMIT, JOS. M. City Engineer & Water Works Supt., P. O. Box 931, Lewistown, Mont. .... Apr. 10, 1926
SCHMITT, CHARLES F. Engr. of Distribution, Water Dept., 1688 E. 84th St., Cleveland, Ohio .... June 17, 1926
*SCHNABEL, WILLIAM R., C.E. Engineer Bureau of Water, 242 S. Madison St., Allentown, Pa. .... Apr. 10, 1924
SCHNEIDER, ERNST J. Supt., City Street & Water Dept., Cedarburg, Wis. .... July 30, 1925
*SCHNEIDER, GEORGE. Supt., Monroe City Water Dept., 125 W. Russell Street, Monroe, Wisc. .... June 16, 1925
*SCHNEIDER, WILLIAM J. Gen. Mgr., Bettendorf Water Co., Bettendorf, Iowa .... Nov. 24, 1924
SCHOLZ, ROBERT O. Senior Engr. Division of Water, 45 Seymour Ave., Newark, N. J. .... Feb. 19, 1916
*SCHONERT, CHAS. O. Supt. Water Works, Hammond Water Department, Hammond, Ind. .... May 28, 1926
*SCHOONMAKER, GEORGE N. 1609 North Erie St., Toledo, Ohio .... Aug. 22, 1921
SCHROEDER, E. C. Manager, Water Works Plant, 617 N. 10th St., Manitowoc, Wis. .... Aug. 26, 1924
SCHUCK, H. W. Supt., Water Department, 804 Bayswater Avenue, Burlingame, Calif. .... June 6, 1927
SCHUMPERT, HOMER W. P. O. Box 333, Newberry, S. C. .... Aug. 24, 1925
*SCHUYLER, PHILIP. Editor, "Western Construction News," 114 Sansome St., San Francisco, Calif. .... Mar. 6, 1926
*SCHWABE, WALTER P. P. & M. The Thompsonville Water Co., 15 Central St., Thompsonville, Conn. .... Nov. 3, 1914
SCHWABEL, FRANK. Supt., Gas & Water Depts., Clearwater, Fla. .... Mar. 31, 1927
SCHWADA, JOSEPH P. City Engineer, 923 49th St., Milwaukee, Wis. .... May 28, 1924
*SCHWARZ, EUGENE. Supt., City Water Dept., Rochester, Minn. .... June 6, 1927

Schweppe, William Haskell. New Canaan, Conn .... Mar. 23, 1928
Schwier, Elmer C. Auditor, Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind .... Dec. 29, 1924
Scofield, C. L. Canadian Fire Und. Assn., 524 Coristine Bldg., Montreal, Canada .... Apr. 22, 1920
*Scott, J. Sheldon. Chst. in Chge. Purification Plant., 1623 State St., Steubenville, Ohio .... Nov. 27, 1920
Scott, John Russell. Ross & Scott, Civil Engrs., 89 Main St., East, Welland, Ont., Canada .... Feb. 28, 1928
Scott, Rossiter, S., M. E. With Nicholas S. Hill, Jr., 112 E. 19th St., New York, N. Y .... Mar. 4, 1922
*Scott, Walter M. Chrmn. of Comnrs., Greater Winnipeg Wtr. Dist., New Civic Offices, Winnipeg, Manitoba, Can. Mar. 11, 1914
*Scott, Warren J. Director, Bureau of Sanitary Engineering, Conn. State Dept. of Health, Hartford, Conn ..... Oct. 14, 1922
*Seery, Francis J. Prof. Hyd. Eng., Cornell Univ., 504 University Ave., Ithaca, N. Y .... Nov. 3, 1919
Seibert, Joseph. Supt. Water Works, St. Cloud, Minn ...... June 5, 1912
*Seligman, Felix. Pump Station, Duluth, W. & L. Dept., Lakewood, Minn .... June 11, 1924
Senior, Samuel Palmer. Pres. & Engr. Bridgeport Hyd. Co., Bridgeport, Conn .... July 10, 1906
*Senseman, H. L. Supt., Water Department, Box 604, Iron Mountain, Mich .... May 24, 1927
*Serkes, Meyer. 1324 Goodfellow Ave., St. Louis, Mo ..... May 25, 1926
*Sevier, Roscoe. Asst. Sect., Los Angeles County Water Works, Gardena, Cal .... Sept. 16, 1927
*Shaneman, Fred C. Sales Engr., Great Western Electro-Chem. Co., 301 Washington Bldg., Tacoma, Wash ...... Jan. 17, 1928
Shaner, George A. Chemical Engineer, The Carter Oil Co., Box 2045, Tulsa, Okla .... Feb. 24, 1928
Sharon, John J. Spring Valley Water Co., 425 Mason Street, San Francisco, Calif .... Feb. 10, 1920
*Sharp, A. S. Mgr. & Sect., Leadville Water Co., 719 Harrison Ave., Leadville, Colo .... Mar 24 1926
Shaw, A. W. Engineer, Box 1516, Brandon, Manitoba, Can ... Jan. 1 1911
Shaw, C. M. Supt., Water Works, P. O. Box 822, Prescott, Arizona .... Apr. 18, 1922
Shaw, Clark H. Chf. Engr., Long Beach Water Dept., 607 City Hall, Long Beach, Calif .... June 29, 1928
Shaw, Frank Russell, B.E. Sanitary Engineer, U. S. Public Health Service, Municipal Bldg., Chicago, Ill .... June 29, 1928
Shaw, Harry B. Asst. Engr., Washington Subn. San. Dist., Hyattsville, Md .... Apr. 2, 1923
Shaw, Walter A. State Public Utilities, 1509 Farwell Ave., Chicago, Ill .... July 10, 1906
Sheal, Robert E. Cons. Engineer, 2101 East 100th St., Cleveland, Ohio .... June 13, 1921
*Shell, R. G. Supt. Filtration Plant, R. F. D. No. 4, Fayetteville, N. C .... June 11, 1924
Sherman, Arthur L. 20 Clinton St., Newark, N. J .... Feb. 16, 1924
Sherman, Charles W. Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass .... May 14, 1914
*Sherman, LeRoy K. Pres., Randolph-Perkins Co., 1444 First National Bank Bldg., Chicago, Ill .... Sept. 10, 1924
*Sherrerd, Morris R. Cons. Engr., Dept. Street & Public Improvts., City Hall, Newark, N. J .... June 7, 1897
*Shibley, Kenneth. Manager, California Filter Co., 202 Securities Bldg., Seattle, Wash .... Sept. 1, 1915

SHIELDS, W. S. Messrs. Shields, Jordan & Roe, 205 W. Wacker Drive, Chicago, Ill.	May 17, 1899
SHIPMAN, EUGENE H. Prest. Clear Springs Water Co., 624 North Main St., Bethlehem, Pa.	July 14, 1920
SHOEMAKER, G. E. Genl. Mgr., Water Works, Waterloo, Iowa,	June 5, 1911
*SHOWELL, E. B., JR. Dupont-Rayon Co., Drawer B, Station B, Buffalo, N. Y.	Nov. 10, 1925
SHONERD, R. E. Asst. Chf. Mechanical Engineer, 1006 Hall of Records, Los Angeles, Calif.	June 29, 1928
*SHORT, WM. B. City Engr. & Supt. Water Works, City Hall, Anacortes, Wash.	Dec. 23, 1927
*SHULL, J. W. Engineer, City Water Dept., 509 Market St., Wheeling, W. Va.	Nov. 24, 1924
*SICKEL, H. B. ALLEN. Vice Pres., Layne-Ohio Co., Box 37, Station D., Columbus, Ohio.	July 22, 1927
*SIDDONS, JOS. S. V. Supt., Torresdale Filters, 1648 Dyre St., Frankford, Philadelphia, Pa.	Feb. 28, 1916
*SIEBERT, CHRISTIAN L. Executive Engr., Penna. Sanitary Water Board, Harrisburg, Pa.	Feb. 8, 1926
SIEDLE, ADOLPH G. Asst. Engr., Water Dept., 480 East 124th St., Cleveland, Ohio	June 13, 1921
*SIEMS, V. BERNARD. Vice President & Chief Engineer, National Water Works Corp., 11 Broadway, New York, N. Y.	May 11, 1916
*SIMMS, R. B. Supt. Water Works, Spartanburg, S. C.	May 24, 1922
*SIMONS, GEORGE W., JR. San. Engr., 364 Avondale Ave., Jacksonville, Fla.	July 23, 1920
*SIMPSON, J. H. 4770 Wallingford St., Oakland Station, Pittsburgh, Pa.	Sept. 11, 1924
*SIMPSON, NATHAN A. Asst. Bact. Bureau of Water, 3818 Lancaster Ave., Philadelphia, Pa.	June 6, 1927
SINGLETON, M. T. Civil Engineer, P. O. Box 1878, Atlanta, Ga.	Sept. 18, 1925
*SKIDMORE, JAMES E. Local Mgr., Hydro Electric Power Commission, Cobourg, Ont., Canada	Mar. 16, 1926
*SKINKER, THOMAS JULIAN. Engr. in Charge of Distribution, 4600 McRee Ave., St. Louis, Mo.	July 31, 1924
SKINNER, ALFRED E. Western Mgr. Pitometer Co., 5311 Kenmore Ave., Chicago, Ill.	Mar. 14, 1921
*SKINNER, HERVEY J. Pres., Skinner, Sherman & Esselen, Inc., 246 Stuart St., Boston, Mass.	Apr. 10, 1926
SKINNER, JOHN F. Deputy City Engr., 56 City Hall, Rochester, N. Y.	May 11, 1927
*SLACK, MORRIS C. 16 Jeannette St., Albany, N. Y.	Jan. 26, 1926
*SLATER, E. O. Chemical Engr., 245 So. Los Angeles St., Los Angeles, Calif.	Apr. 11, 1922
*SLAUGHTER, J. M. Supt., Water Works, Meridian, Miss.	May 28, 1924
SLEEPER, WM. H. Supt. Greenlawn Water District, Greenlawn, L. I., N. Y.	May 16, 1923
*SMALLEY, JAMES D. Supt. Water Dept., 1027 B St., Hayward, Ala. Co., Calif.	Aug. 29, 1923
*SMALSHAF, A. J. Columbus Water Works, Columbus, Ga.	Dec. 26, 1916
SMART, E. E. Commissioner of Water Sanitation, Mineral Wells, Texas	June 6, 1927
*SMEDBERG, C. W. Water Dept., Greensboro, N. C.	Dec. 11, 1922
*SMITH, ALBERT B. 34 East Grand Ave., St. Louis, Mo.	Jan. 25, 1926
SMITH, ARTHUR. East Ely, Nevada	May 20, 1925

SMITH, ARTHUR H. 100 Beechwood Ave., Bound Brook, N. J.. May 8, 1918
*SMITH, CHESTER A. Cons. Engr., c/o Burns-McDonnell-Smith Engr. Co., 422 Western Pacific Bldg., Los Angeles, Cal. Sept. 27, 1924
*SMITH, E. E. Manager, Boise Water Corp., Boise, Idaho... Apr. 23, 1927
*SMITH, E. H. New Jersey Water Co., 521-23 Federal St., Camden, N. J. Apr. 20, 1924
*SMITH, ELROY G. Cons. Engr., 313 Herald Bldg., Augusta, Ga. June 16, 1920
SMITH, L. B. Mgr. Westmoreland Water Co., Greensburg, Pa. July 26, 1915
*SMITH, LEON A. Supt. Water Works, City Hall, Madison, Wis. May 17, 1916
SMITH, M. C. Engineer in Charge Bureau Water & Electricity, Room 109, City Hall, Richmond, Va. May 12, 1925
*SMITH, MILTON PERRY. Supt., Parks & Public Property, Sioux City, Iowa. Apr. 23, 1924
*SMITH, DR. O. M. Chemistry Dept., A. & M. College, Stillwater, Okla. Feb. 24, 1928
SMITH, P. A. Treas., The A. P. Smith Mfg. Co., 66 Stanley Rd., South Orange, N. J. May 31, 1927
*SMITH, R. J. Mgr., Sect.-Treas., Perth Hydro-Electric System, Perth, Ont., Canada. June 10, 1911
SMITH, R. L. Supt., City Water Works, City Hall, Montrose, Colo. Apr. 23, 1927
SMITH, W. AUSTIN, City Manager, Fort Pierce, Fla. Dec. 22, 1926
*SMITH, W. CHESTER. City Engineer, City Hall, Oshawa, Ont., Canada. Feb. 8, 1926
SMITH, W. Z. General Manager Water Works, 1678 N. Rock Springs Road, Atlanta, Ga. Apr. 27, 1910
SMITHRIM, E. R. Secty-Treas. Public Util. Comn., Box 55, Strathroy, Ont., Can. Apr. 3, 1919
SNEDEKER, H. L. Local Manager, Willows District, California Water Service Co., Willows, Calif. May 26, 1927
*SNIDOW, HERMAN W. Asst. Engr., State Board of Health, Richmond, Va. June 17, 1926
SNYDER, FREDERIC ANTES. 105 Carnegie Ave., East Orange, N. J. Mar. 13, 1920
*SNYDER, JAMES. Supt. Water Dept., 46 No. Main St., Perry, N. Y. Nov. 10, 1925
*SNYDER, S. B. Supt. Wtr. Wks., 105 S. Madison St., Stoughton, Wis. July 16, 1923
SOLER, PEDRO A. ROSSELL, Civil Engineer, Brasil 1777, Buenos Aires, R. A. Aug. 5, 1927
*SOLOMON, GABRIEL R. Pres., Solomon, Norcross & Keis, P. O. Box 1917, Fort Lauderdale, Fla. Nov. 18, 1925
*SPALDING, GEO. R. Asst. Supt., Filtration & Sanitation, Hackensack Water Co., New Milford, N. J. June 17, 1926
*SPAULDING, CHARLES H. Supt. Water Purification, Dept. of Water Light & Power, Springfield, Ill. July 29, 1924
SPEAR, WALTER E. Municipal Bldg., Room 2224, New York, N. Y. Jan. 8, 1915
*SPEER, CARL, JR. Sanitary Engineer, 7516 Colfax Ave., Chicago, Ill. Dec. 29, 1926
*SPELLER, FRANK NEWMAN. Metallurgical Engr., 1802 Frick Bldg., Pittsburgh, Pa. June 10, 1920
SPENCER, C. A. Supt. Mountain Wtr. Supply Co., 502 First Natl. Bank Bldg., Greensburg, Pa. Oct. 10, 1919

SPENCER, PERCY S., A.M.I.C.E. Resident Engineer, Newport Mon. Corpn. Water Works, Newport, Monmouthshire, England........ May 3, 1922
*SPERRY, WALTER A. Director of Public Service, 630 Pleasant St., S. E., Grand Rapids, Mich........ Dec. 5, 1914
SPIRE, LEONARD S. Chf. Pitometer Operator, Bureau of Water, 50 Lake View Ave., Buffalo, N. Y........ July 5, 1918
SPITZNAGEL, JOSEPH. Supt. of Water & Light, Box 643, Gilbert, Minn........ June 6, 1927
*SQUIRES, ANSON W. Supt., Tampa Water Works Dept., P. O. Box 461, Tampa, Fla........ Mar. 8, 1924
*STALBIRD, JAMES A. Inspection Agua Potable, Augustinas 1336, Santiago, Chile........ Apr. 9, 1925
*STANFIELD, A. C., C. E. Pana, Ill........ Dec. 24, 1914
*STANLEY, WILLIAM E. c/o Pearse, Greeley & Hansen, 6 No. Michigan Ave., Rm. 1710, Chicago, Ill........ Nov. 9, 1922
*STANNARD, JAY L. 212 City Hall Annex, Tacoma, Wash.... Oct. 20, 1926
STARBIRD, H. R. 524 University Bldg., Syracuse, N. Y...... June 13, 1921
*STARKE, WILLIAM. Supt. of Municipal Water Dept., 416—3rd St., City Hall, San Bernardino, Calif........ Nov. 15, 1926
*STARR, RONALD H. B. A. Sc., Engr., Water, Light & Power Comm., Box 708, Orillia, Ont., Canada........ Jan. 16, 1920
*STARTZELL, R. C. Supt. of Water Works, 224 West Mahoning St., Punxsutawney, Pa........ Dec. 20, 1927
STAVA, WILLIAM. Asst. Engr., Calif. R. R. Comm., Hyd. Divn., 2927 Regent St., Berkeley, Calif........ May 17, 1927
STEARNS, HARRINGTON P. Queens Co. Water Co., Far Rockaway, N. Y........ Jan. 22, 1914
STEIN, I. MELVILLE. 3128 W. Coulter St., Philadelphia, Pa. May 26, 1925
STEINBRUEGGE, R. L. Supt., Meter & Inspection Bureau, Water Div., 6452 McCune, St. Louis, Mo........ June 6, 1927
*STEINHAUER, E. Local Manager, Redding District, California Water Service Co., Box 233, Redding, Calif........ May 26, 1927
***STEPHEN, ENG. LT. CMDR. CHARLES, R.N. Supt. Engr., Macdonald College, P. Q., Canada........ Apr. 21, 1916**
*STEPHENSON, FRANK H. Asst. Supt. Water Supply, 2632 Chicago Blvd., Detroit, Mich........ May 24, 1920
*STEPHENSON, J. R. Superintendent City Water Works, Elkhart, Ind........ Jan. 19, 1926
STERN, M. R. Gen. Mgr., Bartlesville Water Co., Wheeling Bank & Trust Bldg., Wheeling, W. Va........ Feb. 17, 1927
STEROSKY, JOSEPH. Supt. Water Dept., 909 Oak St., Port Huron, Mich........ May 28, 1924
*STEVENS, HAROLD C. Consulting Engineer, 266 Fulton Ave., Hempstead, N. Y........ May 9, 1914
*STEVENSON, RALPH A. Supt. Filtration Division, 3425-V. St., Sacramento, Calif........ Sept. 14. 1927
*STEVENSON, W. L. Chf. Engr., Pa. Dpt. of Hlth., P. O. Box 622, Harrisburg, Pa........ May 1, 1922
*STEWART. C. E. Supt., Muncie Water Works Co., 316 S. Mulberry St., Muncie, Indiana........ Jan. 5, 1925
STEWART, E. B. Electrolysis Engineer, East Bay Water Company, P. O. Box 458, Oakland, Calif........ May 28, 1926
*STEWART, E. J. Engineer, Fire Protection, 701 Jackson St., Topeka, Kansas........ Oct. 30, 1926
STEWART, ELON P. Division Engineer of Operation, Dept. of Eng., Div. of W. S. State Tower Bldg., Syracuse, N. Y.... May 6, 1926
STEWART, FRED J. City Engineer, City Hall Bldg., Hollywood, Fla........ Apr. 12, 1920

STEWART, SPENCER W. Prest. Ambursen Constr. Co. Inc., Grand Central Terminal Bldg., New York, N. Y........ Feb. 4, 1921
STICKNEY, GROSVENOR W. City Engineer, 215 So. Washington St., Wheaton, Ill........ June 6, 1927
STOCK, ROLAND H. Civil & Hydraulic Engineer, 511 Thornton St., Aberdeen, Wash........ Feb. 8, 1928
STOLDT, G. F. Hillview, Ill........ Dec. 16, 1922
*STOMPLER, OTTO F. Superintendent Langhorne Spring Water Co., Langhorne, Pa........ Jan. 6, 1926
*STONE, E. W. Analyst, Pueblo Water Works, P. O. Box 818, Pueblo, Colo........ July 22, 1916
STONE, R. D. Pres. & Mgr., 400 Chestnut St., Philadelphia, Pa........ Dec. 16, 1915
STORRIE, WILLIAM, C.E. Confederation Life Bldg., Room 625, Toronto, Ont........ Mar. 11, 1915
*STORRS, JOHN W., C.E. N. H. Pub. Serv. Comn., Concord, N. H........ Oct. 7, 1919
*STOVER, FREDERICK H. Crescent Hill Filters, Louisville, Ky........ June 3, 1912
*STRADLING, F. P. Supt. Kokomo Water Works Co., P. O. Box 369, Kokomo, Ind........ Dec. 29, 1924
*STRANG, JOHN A., C.E. Wallace & Tiernan Co. Inc, 223 E. 9th St., Kansas City, Mo........ Feb. 8, 1923
STREANDER, PHILIP B. 7208 Hazel Ave., Bywood, Upper Darby, Pa........ Dec. 8, 1923
*STREETER, H. W. San. Engr., U. S. Pub. Hlth. Serv., Third & Kilgour Sts., Cincinnati, Ohio........ Apr. 16, 1915
STRINGFELLOW, H. A. Manager, Pipe Division, The Biggs Boiler Works Co., Akron, Ohio........ July 25, 1924
*STROCKBINE, WALTER. Chemist, Bureau of Water, Reading, Pa........ June 6, 1927
*STROHMEYER, JOSEPH S. Asst. Civil Engr. Water Dept., 5007 Wilson Ave., Baltimore, Md........ May 11, 1922
STROUSE, PAUL EWING. City Engineer, Rocky Ford, Col........ Aug. 31, 1923
STRUTHERS, D. L. City Manager, Gastonia, N. C........ Dec. 8, 1923
*SUDHEIMER, GEORGE C. Comnr. Public Utilities, 25 East Fifth Street, St. Paul, Minn........ Mar. 13, 1925
*SUGGS, JOHN H. Durham Water Works, Durham, N. C........ Apr. 4, 1924
*SUHR, L. D. Suhr, Berryman, Peterson & Suhr, 130 N. Wells St., Chicago, Ill........ Mar. 28, 1928
SUITOR, ROY B. Supt. Public Service, Walnut Ave. & 6th St., Niagara Falls, N. Y........ June 20, 1924
*SULLIVAN, C. J. Supt. Water Works, 319 Second Ave. North, Chisholm, Minn........ June 23, 1913
*SULLIVAN, E. C. U. S. Public Health Service, 1025 Exch. Bldg., 130 Madison Ave., Memphis, Tenn........ Apr. 14, 1924
*SUMNER, R. S. Gen. Mgr., Denver Municipal Water Works, 1509 Cleveland Place, Denver, Colo........ Feb. 28, 1925
*SUTER, RUSSELL. Sr. Asst. Engr., Cons. Comn., Albany, N. Y. Oct. 9, 1914
*SUTERS, FRANK. California Water Service Co., 1029 Hunter Dulin Bldg., San Francisco, Calif........ July 11, 1927
SUTHERLAND, IAN M., M.C.E. Engng. Drftsmn. M. M. B.W., 110 Spencer St., Melbourne, Australia........ June 16, 1920
SUTHERLAND, OSCAR. Asst. Supt., Water Dept., Sioux City, Iowa........ June 6, 1927
*SUTTON, ROY E. Superintendent of Water Works, Route 4, Abilene, Kansas........ Feb. 17, 1927
SWAAB, S. M. Cons. Engr., City Hall, Room 210, Philadelphia, Pa........ Mar. 19, 1924

SWANSON, H. E. Supt., Water & Light Dept., Jacksonville, Ill. June 6, 1927
*SWARTZ, MARTIN. Supt. Water & Light Comn., Greenville, N. C. Dec. 10, 1924
*SWEARINGEN, C. V. Chemist, City Water Company, Chattanooga, Tenn. Jan. 2, 1924
*SWEET, E. O., C.E. Birmingham Water Works Co., 1106½ Virginia Ave., Birmingham, Ala. May 19, 1919
*SWITZER, JOHN A. Cons. Engr., Prof. Hydraulic & Sanit. Eng., University of Tenn., Knoxville Tenn. May 10, 1915
SYMONDS, GEORGE B. Filtration Works Superintendent, Mount Charlton, The Caves, North Coast Line, Queensland, Australia. Aug. 16, 1927
SYMONDS, HENRY A. Cons. Hyd. Engr., 75 Crofton Road, Waban, Mass. Feb. 26, 1921
SYMONS, JOHN Q. Foreman Operator, 2056 Main St., San Diego, Calif. Oct. 20, 1926
SYMONS, M. M. Chief Engr., Interstate Water Co., 1009 West Fairfield St., Danville, Ill. Feb. 8, 1915

TABER, GEORGE A. 73 Cornhill, Boston, Mass. June 3, 1912
*TAINTER, F. S., 84 Pine St., New York, N. Y. Oct. 4, 1919
TAIT, ROBERT S. Superintendent of Water, 14 California St., Santa Cruz, Calif. Oct. 27, 1925
*TAKEUCHI, R. Chief Engineer, Municipal Water Works, Osaka, Japan. Dec. 20, 1927
*TALBOT, ARTHUR N. Prof. Municipal & Sanitary Engr., University of Illinois, Urbana, Ill. Aug. 22, 1894
TALBOT, EARLE. Secty. Treasr. & Genl. Asst. Supt., Hackensack Water Co., Box F., Weehawken, N. J. May 1, 1920
TANCO, H. GOMEZ. Civil Engineer, Apartado 151, Bogota, Colombia. Mar. 1, 1924
*TANNER, I. B. Supt. Wtr. Svce. Dpt., Jos. E. Nelson & Sons, 3240 S. Michigan Ave., Chicago, Ill. Sept. 5, 1919
*TARBELL, W. P. City Engr. & Supt. Water Works, P. O. Box 185, Fargo, N. Dak. Feb. 17, 1928
*TARBETT, RALPH E. U. S. Public Health Service "C" Bldg., 16 Seventh St., S.W., Washington, D. C. July 5, 1921
*TATLOCK, MYRON W. Supt. of Sewage Treatment Wks., 905 Ferndale Ave., Dayton, Ohio. Mar. 10, 1928
TATOR, ARTHUR R. c/o Pure Asphalt Products Co., 136 Cator Avenue, Jersey City, N. J. Nov. 29, 1924
TAY, SAMUEL WRIGHT. San. Engr., Territorial Bd. of Hlth., Hawaii, 2413 Lower Manoa Road, Honolulu, T. H. July 14, 1920
TAYLOR, ARTHUR. Cons. Engineer, 743 Petroleum Securities Bldg., 10th & Flower, Los Angeles, Calif. July 31, 1924
*TAYLOR, GEO. R. San. Chmst., 115 Wyoming Ave., Scranton, Pa. May 11, 1908
TAYLOR, STEPHEN H. Supt. Water Works, 312 Municipal Bldg., New Bedford, Mass. June 3, 1919
*TAYLOR, WARREN C. Assoc. Prof. of Civil Engr., Union College, Schenectady, N. Y. Oct. 31, 1924
*TENNANT, C. W. Dist. Mgr., Western United Gas & Elect. Co., Murphysboro, Ill. Feb. 24, 1928
*TENNY, M. K. Chemist, Des Moines Water Works, 10th & Locust Sts., Des Moines, Iowa. Feb. 17, 1927
THANE, H. S. Supt. Water Department, Missoula Public Service Co., Missoula, Mont. Apr. 30, 1926

THERIAULT, EMERY J. Chemist, U. S. Public Health Service, 3rd & Kilgour Sts., Cincinnati, Ohio........ Dec. 15, 1925
THIESSEN, FRANK C. Engineering Dept., R. R. Comm. Madison, Wis........ Oct. 7, 1924
THOMAS, A. H. R. Supt. Waterworks, Box 227, New Toronto, Ont........ Feb. 28, 1923
THOMAS, CHARLES F. 5915 Springfield Ave., Philadelphia, Pa. Aug. 29, 1923
THOMAS, DAVID S. Inspecting Engineer, Board of Fire Underwriters of the Pacific, P. O. Box 1373, Butte, Mont.... Feb. 7, 1927
THOMAS, E. J. Cons. Engr., Box 613, Minot, N. Dak........ Dec. 11, 1922
THOMAS, EDGAR. Supt., Yreka Water Dept., Yreka, Calif... June 6, 1927
THOMAS, M. L. Superintendent Water Works, Gillette, Wyoming........ Mar. 27, 1926
THOMPSON, ALVIN B. Supt. Kennebec Water Dist., Waterville, Me........ June 26, 1919
*THOMPSON, DAVID G. Water Resources Branch, U. S. Geological Survey, Washington, D. C........ Sept. 24, 1924
THOMPSON, E. W. Northwestern Manager, Neptune Meter Co., 474 Glisan St., Portland, Ore........ Dec. 20, 1927
*THOMPSON, RUDOLPH E. Asst. Chst. Filt. Plant, 596 Milverton Blvd., Toronto, Ont........ Mar. 16, 1922
THORPE, GEORGE E. Gen. Mgr., Thorpe Bros. Well Co., 224-226 Atlas Bldg., Des Moines, Iowa........ May 24, 1927
*THUMA, R. A. Supt. Filter Plant, Water Department R. F. D. No. 4, Dayton's Bluff P. O., St. Paul, Minn.. Mar. 13, 1925
*TIEDEMAN, WALTER V. D. Asst. Sanitarian, Div. of Sanit., State Dept. of Health, Elsmere, N. Y........ Oct. 16, 1925
TIMONOFF, V. E. Prof. of Hydraulic Engineering, Ligowka 44, Log 600, Leningrad, U. S. S. R........ Jan. 1, 1921
*TIPPINS, BEN. F. Gen. Supt., Water & Sewerage Plants, 517 Magnolia Ave., Daytona Beach, Fla........ Dec. 22, 1926
*TISDALE, ELLIS S. Director, San. Eng. Division, State Dept. of Health, Charleston, W. Va........ Aug. 26, 1916
TITSHAW, ERNEST P. Box 1814, Atlanta, Ga........ Mar. 16, 1927
TODD, WILLIAM. Supt. Elec. Light & Water Works, Austin, Minn........ June 18, 1901
TOLLES, FRANK C. Civil & Sanitary Engineer, 1149 Leader-News Bldg., Cleveland, Ohio........ Aug. 1, 1923
*TOLSON, ALBERT. Supt. of Filters, 206 Rochelle Ave., Philadelphia, Pa........ Jan. 29, 1916
TOMLINSON, O. N. Mgr. Hermosa Redonda Water Co., P. O. Box 235, Redondo Beach, Calif........ Dec. 10, 1924
TOMLINSON, SAM. 100 Robinson Road, Singapore, S. S........ July 14, 1887
*TOMS, R. C. Mgr. Marion Water Co., Marion, Iowa........ Apr. 4, 1924
TONNEY, FRED O., M.D. Dir. of Laboratories & Research, Dept. of Health, 712 City Hall, Chicago, Ill........ Aug. 28, 1928
*TOTTEN, ROBERT L. Cons. Engr., 415 Brown Marx Bldg., Birmingham, Ala........ Mar. 26, 1923
*TOWLE, ELTON L. Hydraulic & Mechanical Engineer, 341 Hamilton Ave., Glen Rock, N. J........ Apr. 5, 1922
*TRACE, V. E. Supt. Water Works Dept., City Hall, Santa Barbara, Calif........ July 23, 1920
TRAUGER, GEORGE W. Supt. Lindsay Strathmore, Irrigation District, Box 57, Lindsay, Calif........ Nov. 18, 1925
TRAVIS, F. M. Pres., The Torrington Water Co., P. O. Box 76, Torrington, Conn........ July 20, 1917
*TRAX, E. C. Chemist, Filtration Plant, McKeesport, Pa.... June 9, 1911
TREMBLAY, J. A., C.E. Engr., Water & Sewerage Dept., 98 Bougainville Ave., Quebec, Canada........ May 28, 1924

*TRIBUS, LOUIS LINCOLN, C.E. 15 Park Row, New York, N. Y. May 12, 1906
*TRICE, M. F. Assistant Engineer, State Board of Health, Raleigh, N. C. Nov. 19, 1927
*TRIMBLE, EARLE J. Supervising Engr., Water Dept., 85 Otsego St., Ilion, N. Y. May 15, 1924
TRUE, ALBERT O. Sanitary Engr., Proximity Mfg. Co., Denim Branch, Greensboro, N. C. Aug. 28, 1922
*TRUMAN, CHESTER A. Supt., Northfield Land & Water Co., 3011 N. Tejon St., Colorado Springs, Colo. Dec. 27, 1926
TRUMBORE, FRANK J. Master Mechanic, 1151 N. Main St., Pleasantville, N. J. Apr. 7, 1922
*TURNER, J. W. Superintendent, Waterworks, Edmonton, Alberta, Canada. June 6, 1922
TURNER, JOSEPH J. Asst. Sect., Boise Water Co., Box 718, Boise, Idaho. Jan. 14, 1925
*TURRE, GEORGE J. Chief Chemist, Municipal Water Works, Board of Water Comnrs., 1509 Cleveland Place, Denver, Colo. Nov. 19, 1927
*TUTTLE, ARTHUR S. Chf. Engr., Bd. of Estimate & Apportionment, Municipal Building, New York, N. Y. July 10, 1916
*TYLER, O. Z. Superintendent Water Dept., City Engineer Bldg., Jacksonville, Fla. June 17, 1926

*ULRICH, BERNARD L. Supt., Water Works, Manhattan, Kansas. Feb. 20, 1922

VAIL, CHARLES D. Mgr. Improvements & Parks, City Hall, Denver, Col. Jan. 8, 1921
*VANARNUM, WILLIAM I. Supt. Filtration, 374 Glenwood Ave., Youngstown, Ohio. Feb. 7, 1922
VAN ARSDALE, GEORGE A. Water Superintendent, Hugo, Colorado. Apr. 10, 1926
VAN BENSCHOTEN, JAY. Mechanic & Water Works Engr., 32 Front St., W., Toronto, Ont., Canada. June 10, 1923
*VANBRUNT, W. D. Pres. Water Works Co., Southampton, N. Y. Aug. 23, 1920
VAN CAMP. R. K. Commissioner, Public Works, Bradenton, Fla. May 17, 1928
*VAN CLEAVE, SAM M. Supt., City Water Works, City Hall, Marion, Ind. Apr. 10, 1926
*VAN DEN BERG, C., JR. Vice Pres., Alabama Water Co., 1019 American Trust Bldg., Birmingham, Ala. Apr. 23, 1927
*VAN DEUSEN, E. T. Supt., Water Works, 21 Pearl St., Malone, N. Y. Feb. 14, 1925
VAN DOREN, WM. THEO. Water Survey Engineer, Bryant St. Pumping Sta., Washington, D. C. May 18, 1926
VAN GILDER, L. Engr. & Supt. Water Dept., City Hall, Atlantic City, N. J. July 10, 1906
VAN GORDER, J. R. Eastern Sales Manager, Neptune Meter Company, 50 E. 42nd St., New York, N. Y. Mar. 20, 1922
VANKEUREN, C. A. Chief Engr., Wat. Dept., City Hall, Jersey City, N. J. May 23, 1923
*VAN LOAN, SETH M. Deputy Chief, Bureau of Water, 709 City Hall, Philadelphia, Pa. May 12, 1914
VAN TRUMP, S. N. Chf. Engr. & Supt. Water Wks., Wilmington, Del. Feb. 7, 1916
*VAUGHN, W. H. Water Superintendent, Fort Smith, Ark. June 6, 1927
*VEATCH, N. T., JR. Cons. Engr., 701-5 Mutual Building, Kansas City, Mo. Dec. 16, 1915

VERMETTE, NARCISSE J. A. City Manager, Shawinigan Falls, Can........ Feb. 7, 1927
*VERMEULE, CORNELIUS C., C.E. 38 Park Row, New York, N. Y........ June 8, 1909
VERSULIUS, JAS. J. Construction Engineer, 403 City Hall, Chicago, Ill........ June 5, 1926
VERTEFEUILLE, JOSEPH A Municipal Bldg., Brooklyn, N. Y. May 16, 1916
*VEST, W. E. Supt. Water Works, Charlotte, N. C........ May 3, 1911
VIEIRA, E. DE M., C.E. Caixo Postal 70, Campos, Brazil, S. A........ June 23, 1928
*VOGELBACK, WILLIAM E. Southern States Power Co., 100 W. Monroe St., Chicago, Ill........ Feb. 8, 1926
VOJCSIK, LIPOT, C.E. Budapest IX, Ulloi ut 69, Hungary... July 19, 1926
*VOLK, KENNETH Q. 176 No. Highland Ave., Los Angeles, Calif........ Oct. 18, 1926
VOLLMAR, OTTO. Director, Dresden Water Works, Brockhausstrasse 3, Dresden, N. 8, Germ........ Mar. 13, 1925
*VON GREYERZ, WALO, C.E. Capt. Royal Swedish Corps Engrs., Humlegardsgatan 29, Stockholm, Sweden.. July 23, 1920
*VOSBURY, W. DEWITT. Hydraulic & Sanitary Engr., 509 Cooper St., Camden, N. J........ Jan. 19, 1924

*WACHTER, LEONARD M. Chemist, Dept. of Health, 192 Partridge St., Albany, N. Y........ Mar. 16, 1922
WAGGONER, GEORGE. Supt., Carlisle Gas & Water Co., Carlisle, Pa........ May 12, 1925
WAGNER, A. H. Supt., Public Water Works Dist. #2, 119 E. Abriendo Ave., Pueblo, Colo........ Mar. 10, 1928
*WAGNER, C. F. Engr., Oregon Insur. Rating Bur., P. O. Box 745, Portland, Oregon........ Nov. 30, 1925
*WAGNER, EDWIN B. Supt. Water Works, Downingtown, Pa. Apr. 22, 1921
*WAGNER, HENRY F. Chief Chemist, Bureau of Water, Filtration Division, Buffalo, N Y........ May 12, 1914
WAGNER, RICHARD F. Supt. & Engr. Dept. of Water, Lynchburg, Va........ Nov. 3, 1919
*WALDEN, A. E. Supt. & Chief Engineer, 26 Hamilton Ave., Raspeburg P. O., Baltimore, Md........ May 12, 1908
WALDROP, GEORGE G. Secretary, Water Works, Room 3, City Hall, Fort Wayne, Ind........ Apr. 10, 1926
WALKER, CARL C. Civil Engineer, 511-12 Hartman Bldg., Columbus, Ohio........ Jan. 26, 1924
*WALKER, ELTON D. Prof. of Hydrau. & San. Engrg., Pennsylvania State College, State College, Pa........ July 18, 1906
*WALKER, ISAAC S. Vice Pres. & Genl. Mgr., New Chester Water Co., 30 No. Franklin St., Wilkes Barre, Pa..... Mar. 25, 1919
WALKER, J. E. 2 Dalhousie Square, Post Office Box 680, Calcutta, India........ Nov. 12, 1926
WALKER, LEWIS DEWAR. Water Works Engineer, Canadian Fire Underwriters Asso., Metropolitan Bldg., Toronto, Ont., Canada........ Feb. 10, 1921
*WALL, EDWARD E. 5361 Pershing Ave., St. Louis, Mo. .... June 7, 1904
*WALLACE, WILLIAM M. Filter Supt. & Chief Chemist, Filtration Plant, Water Wks. Park, Detroit, Mich........ Apr. 5, 1922
WALSH, JOHN H. 265 Burnside Ave., East Hartford, Conn... May 28, 1924
WARD, CHARLES MAXWELL. Cons. Engineer, E. Laurie Co. 115 Stanley St., Montreal, P. Q., Canada........ June 10, 1920
*WARD, JOE E., C.E. Montgomery & Ward, Cons. Civil Engrs. 545 Harvey-Snider Bldg., Wichita Falls, Texas........ June 17, 1926

*WARD, THOMAS H. P. O. Box 613, Fort Smith, Ark........ May 28, 1924
WARDER, CHARLES. Superintendent Water Works, Niagara Falls, Ont.......... Jan. 8, 1916
*WARING, F. HOLMAN. Chief Engineer, State Dept. of Health, Columbus, Ohio.......... Feb. 23, 1915
WARNECKE, M. H. Supt. Water Works, 216 So. 10th Ave., Maywood, Ill.......... Mar. 27, 1926
WARNER, H. L. Messrs. Crane-O'Fallon Co., 1631—15th St., P. O. Box 239, Denver, Colo.......... Jan. 25, 1927
WARREN, C. A. Const. Engr., City Water Department, 1822 E. Lafayette Ave., Baltimore, Md.......... May 24, 1922
WARREN, HERBERT C. Genl. Mgr., Glendora Cons. Mutual Irr. Co., 234 N. Michigan Ave., Glendora, Calif...... Mar. 16, 1927
WARREN, W. D. P. Cons. Engr., Milliken Bldg., Decatur, Ill. Mar. 20, 1920
*WARRICK, LOUIS F. Asst. Sanitary Engineer, State Board of Health, Madison, Wisc.......... Apr. 6, 1920
*WATERMAN, EARLE LYTTON. Professor San. Engr., 104 Eng. Hall, University Ia., Iowa City, Iowa.......... Dec. 11, 1922
WATKINS, THOMAS. Mechanical Engr., Johnstown, Pa...... May 18, 1892
WATSON, WILLIAM. Supt., Water & Light Dept., City Hall, Owensboro, Ky.......... Mar. 8, 1924
*WATT D. M. Mgr. American Water Works & Elec. Co., 50 Broad St., New York, N. Y.......... Apr. 23, 1924
WATT, H. E. Supt. Huntington Water Corpn., Huntington, W. Va.......... Aug. 13, 1924
WATTS, H. T., C.E. Supt. Water Supply Co., Box 107, Vincennes, Ind.......... July 7, 1920
*WATZL, ERNST. President, Watzl-Schweitzer, Inc., 502 Huron-Sixth Bldg., Cleveland, Ohio.......... Aug. 30, 1928
WEAVER, ALLEN J. Chemist, Commercial Testing, P. O. Box 28, Jacksonville, Fla.......... May 31, 1928
WEAVER, F. F. Chemist, General Chemical Co., P. O. Box 147, Long Island City, N. Y.......... Dec. 13, 1924
*WEAVER, S. M. Superintendent Water Works, Monroe, Mich.......... Jan. 19, 1925
WEBB, S. W. Dist. Mgr. Consumers Power Co., Cadillac, Mich.......... Jan. 8, 1921
WEBSTER, WADE L. Director Public Works, Kingsport, Tenn. Dec. 20, 1926
WECHTER, W. E. 704 Passaic Ave., Orlando, Fla.......... Apr. 23, 1927
*WEED, ELLSWORTH S. Civil Engineer, 232 Maclay St., Harrisburg, Pa.......... July 12, 1926
*WEED, FREDERICK H. Gannett, Seelye & Fleming, 600-602 North 2nd St., Harrisburg, Pa.......... Nov. 10, 1925
*WEIDLEIN, E. R. Sc.D., Mellon Ins. of Ind. Research, Thackeray & O'Hara Sts., Pittsburgh, Pa.......... June 26, 1924
*WEIR, W. H. Georgia State Board of Health, 4 Capitol Square, S.W., Atlanta, Ga.......... Dec. 29, 1924
WEIR, W. V. 6600 Delmar Blvd., University City, Mo...... July 14, 1924
WEISENBERGER, VICTOR. Supt. Tell City Water Dept., Tell City, Ind.......... May 17, 1928
WELFELT, W. J. City Manager & Water Supt., Winfield, Kansas.......... June 6, 1927
WELLS, GEORGE M. Consulting Engineer, 61 Broadway, New York, N. Y.......... May 5, 1913
WELLS, MARVIN. Superintendent Water Works, 1333 Washington St., Des Plaines, Ill.......... June 17, 1926
*WELSFORD, HENRY REED. Supt., Belmont Filter Plant, Bur. of Water, Belmont Ave., & Ford Road, Philadelphia, Pa.......... Apr. 23, 1927

*WENDLER, WALTER H. Sanitary Engineer, Box 421, Dallas, Tex........ Jan. 10, 1928
WENTWORTH, FRANKLIN H. Sect., National Fire Protection Assoc., 40 Central St., Boston, Mass........ May 28, 1924
WENTWORTH, JOHN P. Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass........ July 10, 1926
*WERTZ, C. F. 1843 W. Erie Ave., Philadelphia, Penna...... Mar. 25, 1924
WERTZ, R. D. Southeastern Representative, R. D. Wood & Co. of Phila., 113 So. "N" St., Lake Worth, Fla...... Apr. 12, 1928
*WESLEY, J. B. Missouri Pacific Railroad Co., 1310 Mo. Pac. Bldg., St. Louis, Mo........ Apr. 24, 1922
WEST, CHAS. C. Gen. Mgr., Sayre Water Co., Sayre, Pa. Dec. 21, 1922
WEST, GEO. F. President, Biddeford & Saco Water Co., Portland, Me........ July 24, 1911
*WEST, GEORGE M. Supt., Post Office Bldg., 182 S. 2nd St., Lehighton, Pa........ Mar. 17, 1916
*WEST, VERNON F. Rensselaer Water Co., Box 868, Portland, Maine........ June 19, 1914
*WESTON, ROBERT SPURR. Consulting Sanitary Engr., 14 Beacon St., Boston, Mass........ June 15, 1898
*WETTER, CLARENCE H. Supt. Water Works, Tiffin, Ohio... July 15, 1915
*WHEDBEE, EDGAR. District Sanitary Engineer, Texas State Board of Health, 601 W. 10th St., Bonham, Texas..... June 17, 1926
*WHEELER, ROBERT C. Barker & Wheeler, 36 State St., Albany, N. Y........ Oct. 23, 1914
*WHEELER WILLIAM. Consulting Civil Engr., 14 Beacon St., Boston, Mass........ July 10, 1906
*WHIPPLE, MELVILLE C. Asst. Prof. of Sanitary Chemistry, 112 Pierce Hall, Cambridge, Mass........ May 13, 1922
WHITACRE, R. D. Supt. of Water Dept., City Hall, Tucson, Ariz........ Sept. 28, 1926
WHITE, CHARLES H. Supt. Water Dept., Box 744, Asbury Park, N. J........ May 28, 1924
*WHITE, GEORGE W. Civil Engr., Harwood Beebe Co., 12 Glenn Bldg., Spartanburg, S. C........ Dec. 29, 1924
WHITE, GILBERT C., C.E. Durham, N. C........ May 12, 1908
*WHITE, GUY H. Superintendent Water Plant, 2217 Gadsden St., Columbia, S. C........ Nov. 24, 1925
WHITE, HENRY M. Supt., Water Works, Oneida, N. Y...... May 24, 1922
WHITE, I. A. Superintendent Water Works, Bessemer City, N. C........ Dec. 8, 1923
*WHITENER, J. SUMMIE. 1202 Cowper Drive, Raleigh, N. C. Dec. 13, 1924
*WHITMAN, EZRA B. Civil & Sanitary Engr., 18 E. Lexington Street, Baltimore, Md........ Apr. 19, 1910
WHITMIRE, C. D. 5725 Grand Ave., Kansas City, Mo....... Apr. 13, 1926
WHITSIT, LAWRENCE C. City Engineer, 110 California Ave., Highland Park, Mich........ May 7, 1917
*WHITTAKER, H. A. Director, Division of Sanitation, State Board of Health, Minneapolis, Minn........ June 24, 1913
*WIEDEMAN, H. F. Wiedeman & Singleton, Inc., P. O. Box 1878, Atlanta, Ga........ Mar. 27, 1925
*WIEGHARDT, GEORGE F. Hydraulic Engineer, 433 Ogden Ave., West Englewood, N. J........ Mar. 25, 1924
*WIETERS, A. H. Chf. Engr., Div. of Sanitary Eng. & Housing, State Dept. of Health, Des Moines, Iowa........ Nov. 14, 1921
WIGGIN, THOMAS H. Cons. Engr., 40 Exchange Place, New York, N. Y........ May 24, 1922
*WIGHT, H. C. Industrial Engr., 806-7 Dayton Savings & Trust Bldg., Dayton, Ohio........ May 12, 1915

Wigley, Chester G., C.E. Room 230, Guarantee Trust Bldg., Atlantic City, N. J. .... Apr. 27, 1910
*Wilbur, C. C. R. I. Box 15, Fridley, Minn. .... Feb. 20, 1924
Wilcox, Frank L. Cons. Engr., Chemical Building, St. Louis, Mo. .... Apr. 28, 1914
Wilcox, William F., M.E. 1205 Fourth National Bank Bldg., Atlanta, Ga. .... Sept. 5, 1893
Wiley, Richard E. Dist. Mgr., Oregon-Wash. Water Service Co., 1131 Second St., Hillsboro, Ore. .... Jan. 26, 1928
Wilhelm, E. G. Secty-Treasr., Williamsport Water Co., Williamsport, Pa. .... Feb. 15, 1917
Wilhelm, George. Chief Engr. East Bay Water Co., Oakland, Cal. .... Mar. 25, 1913
*Wilkinson, L. J. Charge of Water Rectification Dept. Riley Eng. & Supply Co. Ltd., 360 Dufferin St., Toronto, Ont., Canada .... Feb. 4, 1928
Will, Charles K. Supt. Water Works, 118 S. Queen St., Lancaster, Pa. .... Feb. 19, 1919
Willard, Ernest C. 720 Corbett Building, Portland, Oregon .... Oct. 10, 1914
*Willcomb, George E. San. Engr., 12 So. Lyons Ave., Albany, N. Y. .... Apr. 7, 1922
*Willett, J. F. Supt. City Water Dept., Billings, Mont. .... Apr. 28, 1915
Willett, William N. Genl. Mgr. Murphysboro Wtr. Wks., Elect. and Gas. Light Co., Aurora, Ill. .... Sept. 21, 1918
Williams, D. M. Assistant Engr., c/o Wm. M. Piatt, Durham, N. C. .... May 18, 1923
Williams, Gardner S. Cons. Engr., Cornwell Bldg., Ann Arbor, Mich. .... July 10, 1906
Williams, Howard L. Supt. Water Works, Ludington, Mich. Aug. 24, 1894
Williams, Leon G. Civil Engr., Messrs. Pearse, Greeley & Hansen, 6 No. Michigan Ave., Chicago, Ill. .... July 23, 1928
Williams, O. E. Pres., Marion Water Co. & Tiffin Water Wks., 42 S. Russell St., P. O. Box 3378, Boston, Mass.. June 6, 1927
Williams, R. B., Jr. General Manager, Onondaga Water Service Corp., 148 No. Warren Street, Syracuse, N. Y. Mar. 19, 1926
*Williamson, D. Charles. 5 Orchard St., Bernardsville, N. J. Jan. 16, 1923
Williamson, James E. Cons. Engr., 39 Cortland St., New York, N. Y. .... Jan. 20, 1921
*Wills, W. Compton. Assistant Engineer of Distribution, Water Dept., 16th and French Sts., Wilmington, Dela. July 10, 1926
Willson, William Jay. Supt. Water Works, Greenwich, Conn. .... June 7, 1916
Wilson, Carl. Bacteriologist, Los Angeles Water Dept., Los Angeles, Calif. .... June 30, 1928
Wilson, Edgar Kennard. 54 Carolin Road, Upper Montclair, N. J. .... Mar. 6, 1926
Wilson, Everitt W. 43 Austin Ave., Asheville, N. C. .... Dec. 20, 1925
*Wilson, Gordon. C. E., 12 Oxford Terrace, West Orange, N. J. .... Sept. 30, 1928
*Wilson, I. E. Wtr. Commissioner, City Hall, Faribault, Minn. .... Sept. 21, 1922
Wilson, J. P. City Clerk, Titusville, Fla. .... Apr. 12, 1928
Wilson, Jesse H., C.E. City Engineer, Idaho Falls, Ida. .... July 31, 1924
Wilson, John. City Hall, Duluth, Minn. .... Dec. 22, 1909
*Wilson, John F. Dist. Mgr., Oregon-Wash. Water Service Co., 209 So. First St., Mount Vernon, Wash. .... Jan. 26, 1928

*WILSON, JOHN J. District Engineer, Natl. Tube Co., 1020 First Natl. Bank Bldg., Denver, Colo.......... Mar. 10, 1926
WILSON, NORMAN McLEOD RAMSAY. Chf. Engr., Water Comnrs., Brantford, Ont., Canada.......... Dec. 26, 1919
WILSON, PERCY S. Superintendent of Operation, Community Water Service Co., 46 Cedar St., New York, N. Y. July 16, 1926
WINKLE, CHARLES W. Supt., Maintenance & Transportation, Indianapolis Water Co., 620 W. Market St., Indianapolis, Ind.......... Dec. 29, 1924
*WINSLOW, C.-E. A. Yale Medical School, New Haven, Conn.. Jan. 30, 1915
WINSLOW, W. H. Vice Prest. Superior W., Lt. and Pr. Co., Superior, Wis.......... June 8, 1909
*WINSOR, FRANK E. Chf. Engr., Metropolitan Dist. Water Supply Commission, 24 School St., Boston, Mass.......... Jan. 26, 1924
*WINTERMUTE, FERD C., C.E. 404 Second National Bank Bldg., Wilkes Barre, Pa.......... Dec. 16, 1922
*WINTGENS, PETER J. Supt. Wtr. Wks., 1201 Fifth Ave., Ford City, Pa.......... May 23, 1923
WOLBERT, H. E. Supt. Bd. of Water Supply, Mount Vernon, N. Y.......... May 26, 1916
WOLF, H. CARL. Chief Engr. Public Serv. Comm., 1724 Munsey Bldg., Baltimore, Md.......... Feb. 27, 1924
WOLFE, ED. C. Supt. Water & Light, 211 S. State St., Greenfield, Ind.......... Dec. 29, 1924
*WOLFE, EDWARD E. Chemist, Water Dept., Hannibal, Mo.... Apr. 24, 1922
WOLFE, THOMAS F. Resrch. Engr., Cast Iron Pipe Pub. Bur. 566 Peoples Gas Bldg., Chicago, Ill.......... Mar. 16, 1922
*WOLMAN, ABEL. San. Engr., 2411 No. Charles Street, Baltimore, Md.......... Mar. 11, 1918
*WOLTMAN, J. J., C.E. 225 Unity Bldg., Bloomington, Ill... May 20, 1923
*WOOD, C. LELAND. Supt. of Municipal Commission, Herkimer, N. Y.......... July 19, 1927
WOOD, LEONARD P. Asst. Engr., Board of Water Sup. of N. Y. C., 2217 Municipal Bldg., New York, N. Y.......... Mar. 5, 1924
*WOODS, HARLAND CLARK. 442 Grove St., E. Lansing, Mich.. Aug. 14, 1919
*WOODWARD, FRANK L. Jr. San. Engr., Minnesota Dept. of Health, Minneapolis, Minn.......... May 11, 1927
WOOLLEY, JAMES. Meter Laboratory Chf., 135 4th St., Newark, N. J.......... June 21, 1920
WOOLNOUGH, FREDERICK, J. 1364 Albany Ave., Brooklyn, N. Y.......... Apr. 14, 1924
WORTH, A. M. City Hall, Durham, N. C.......... Apr. 23, 1924
WORTHINGTON, STANLEY W. Engr., Rochester & Lake Ont. Water Serv. Corp., 440 Powers Bldg., Rochester, N. Y. May 22, 1928
WRAY, WALTER. Box 487, Tustin, Calif.......... Nov. 11, 1926
WRIGHT, C. F. Supt., Light & Water Dept., Lake Worth, Fla.......... Jan. 25, 1927
WRIGHT, C. W. Pres., Badger Meter Mfg. Co., 841—30th St., Milwaukee, Wis.......... Mar. 19, 1927
WRIGHT, E. L. Superintendent, Municipal Water Works, Orland, Glenn Co., Calif.......... June 20, 1922
WRIGHT, HOWELL. Director of Public Utilities, 204 City Hall, Cleveland, Ohio.......... June 17, 1926
WRIGHT, JAS. Supt., Dundas Water Works, Dundas, Ont., Canada.......... Apr. 29, 1924
*WRIGHT, JOHN G. Engr. and Filter Operator, 312 Lincoln St., Sayre, Pa.......... June 30, 1921

*WRIGHT, LEROY H. Superintendent of Water Works, 516 Colton Ave., Newark, N. Y.	Apr. 12, 1927
*WRIGHT, STANLEY HUBERT. Consulting & Hydraulic Engr., City Hall, Asheville, N. C.	July 13, 1923
*WUESTE, R. G. City Hall, San Diego, Calif.	May 12, 1925
WYANT, CARL. Resident Engr., Montecito County Water Dist., 29 San Ysidro Rd., Santa Barbara, Calif.	Mar. 5, 1924
WYCKOFF, CHARLES R. 1239 N. Y. Post Rd., Scarsdale, N. Y.	Apr. 2, 1918
*WYCKOFF, NORMAN R. Dept. of Water Supply, Detroit, Mich.	Sept. 11, 1923
*WYNNE-ROBERTS, R. O. Suite 902, Metropolitan Bldg., 44 Victoria St., Toronto 2, Ont. Canada	June 24, 1903
*YACKLEY, WILBUR A. Chemist & Bacteriologist, Department of Water, Ottawa St., Dayton, Ohio	Jan. 17, 1928
*YAXLEY, R. GORDON. Supt. to Water Commissioners, Waterford, N. Y.	Oct. 13, 1925
*YEGEN, WILLIAM. Supt. of Filtration Plant, 808 Main Avenue Bismarck, N. D.	June 6, 1927
YODER, JOSEPH D. Water Purification Engineer, Cochrane Corporation, 17th St. and Allegheny Ave., Philadelphia, Pa.	Feb. 8, 1926
*YOUNCE, W. L. 121 S. 7th St., Newcastle, Ind.	July 1, 1924
YOUNG, GEORGE RICHMOND. Village Manager, Village Hall, Glencoe, Ill.	July 9, 1928
YOUNG, T. L. Mgr. South Side Water Works Co., Chester, W. Va.	June 13, 1921
YOUNG, WM. R. Registrar Water Works, City Hall, Minneapolis, Minn.	June 8, 1904
ZELL, T. H. Superintendent Water Dept., Xenia, Ohio	May 23, 1923
*ZILKER, ANDREW J. 301 East 2nd Street, Austin, Tex.	Apr. 27, 1925
ZIMMERLIN, HARRY F. Supt. of Water, Lyons, N. Y.	June 3, 1921

CORPORATE MEMBERS

ADIRONDACK WATER WORKS. H. N. Heberer, Lowville, N. Y.	Jan. 12, 1923
*AGUA PURA CO. 701 Douglas Ave., East Las Vegas, N. M.	May 24, 1909
*ALABAMA POWER CO. Howard Duryea, Asst. to General Manager, Birmingham, Ala.	Feb. 23, 1926
ALEXANDRIA WATER CO. Alexandria, Va.	Apr. 3, 1909
ALLENTOWN WATER DEPARTMENT. City Hall, Allentown, Pa.	May 31, 1922
AMERICAN WATER WORKS AND ELECTRIC CO., INC. Mr. H. Hobart Porter, Prest., 50 Broad St., New York, N. Y.	June 24, 1915
ANACONDA COPPER MINING CO. Water Works Dept., Anaconda, Mont.	June 4, 1910
ANN ARBOR WATER WORKS COMMISSION. City Hall, Ann Arbor, Mich.	Apr. 14, 1919
ANTIOCH, CALIF. John F. Linwood, City Hall, Antioch, Calif.	Sept. 30, 1926
ARKANSAS POWER & LIGHT CO. Pine Bluff, Arkansas	May 18, 1909
ARKANSAS UTILITIES COMPANY. 311 Porter Street, Helena, Arkansas	May 12, 1925
ASHLAND WATER COMMISSION. E. C. Means, Chairman, Ashland, Ky.	Apr. 10, 1925
ASHTABULA WATER SUPPLY CO., A. T. Faulkner, Manager, Ashtabula, Ohio	Mar. 5, 1924
*AUBURN WATER DEPARTMENT. Auburn, New York	Mar. 8, 1911
BATON ROUGE WATER WORKS CO. Baton Rouge, La.	Apr. 13, 1914
BAY CITY WATER WORKS DEPT. City Hall, Bay City, Mich.	Aug. 24, 1925
*BENICIA WATER CO. J. A. Wilcox, Chf. Engr., 603 Wells Fargo Bldg., San Francisco, Cal.	May 29 1920
*BETHLEHEM, PENNA., CITY OF. 37 E. Broad Street, Bethlehem, Pa	Apr. 27, 1925
BEVERLY HILLS WATER DEPARTMENT. C. L. Kimball, Field Supt., City Hall, Beverly Hills, Cal	Sept. 21, 1926
BIRMINGHAM WATER CO. 22 Elizabeth St., Derby, Conn.	May 26, 1909
BOULDER WATER DEPARTMENT. E. W. Devalon, Director of Public Serv., Boulder, Colo.	Jan. 27, 1927
*BRAMPTON WATER COMMISSION. Brampton, Ont., Canada	Feb. 28, 1923
BRANTFORD WATER COMMISSIONERS. Brantford, Ont., Canada	May 15, 1914
BUFFALO, Bureau of Water, 2 Municipal Bldg., Buffalo, N. Y.	June 9, 1921
BURBANK, CALIF. Public Service Department, J. H. McCambridge, Genl. Supt., 124 N. Olive, Burbank, Calif.	June 6, 1927
*CANON CITY, COLO. Alfred W. Stedman, Water Supt. & Plumbing Inspector, City Hall, Canon City, Colo	Apr. 13, 1926
CENTRAL ILLINOIS PUBLIC SERV. CO. D. W. Johnson, Water Engr., Public Service Bldg., Springfield, Ill	Mar. 22, 1927
CHARLESTON COMMISSIONERS OF PUBLIC WORKS, 14 George St., Charleston, S. C.	May 23, 1912
CHATHAM, ONT. Board of Water Commissioners, C. H. R. Fuller, City Mgr., Chatham, Ont., Canada	Feb. 16, 1924
CITIZENS WATER CO. 62 E. Wheeling St., Washington, Pa.	Jan. 6, 1927
*CITIZENS WATER SUPPLY CO. Elmhurst, Long Island, N. Y.	Jan. 30, 1911
COMMUNITY WATER SERVICE CO. Reeves J. Newsom, Vice Pres., 46 Cedar St., New York, N. Y.	Jan. 6, 1927

CONNECTICUT STATE DEPT. OF HEALTH. 8 Washington Street, Hartford, Conn. .... Sept. 6, 1924
CONSERVATIVE WATER CO. W. W. Pedder, Pres., 8619 Fir St., Los Angeles, Cal. .... Nov. 3, 1919
CORNING WATER WORKS. Corning, N. Y. .... Apr. 9, 1913
CRESTON, IOWA. Taxpayers Municipal Water Works, Creston, Iowa .... May 10, 1919

DALLAS CITY WATERWORKS. S. E. Moss, Commissioner, Dallas, Texas .... June 6, 1927
DAYTON POWER & LIGHT CO. 130 North South St., Att'n H. I. Fox, Supt., Wilmington, Ohio .... Feb. 16, 1924
*DELAVAN WATER COMMISSION. O. W. Blanchard, Supt., Delavan, Wis. .... June 10, 1923
DEMING WATER DEPT. Municipal Plant, Deming, N. Mex. May 21, 1919
DOVER WATER COMMISSIONERS. Jos. V. Baker, Clerk, Morris Co., Dover, N. J. .... May 22, 1918
DUBUQUE CITY WATER WORKS. J. W. McEvoy, Supt., Dubuque, Ia. .... May 13, 1919
DUNBAR WATER CO. Dunbar, W. Va. .... Mar. 19, 1924

*EAST BAY WATER CO. S. M. Marks, Secy., Oakland, Calif.. June 24, 1915
EAST ORANGE BOARD OF WATER COMMISSIONERS. Paul C. Carey, President, East Orange, N. J. .... Aug. 14, 1909
*ELLWOOD WATER CO. 835 Lawrence Ave., Ellwood City, Pa. .... Jan. 19, 1925
ELMIRA WATER BOARD. Elmira, N. Y. .... Mar. 11, 1915
EMPORIA WATER DEPARTMENT. City Bldg., Emporia, Kans.. Jan. 16, 1924
*EMPORIUM WATER CO. Emporium, Pa. .... Mar. 6, 1926
ENDICOTT WATER WORKS CO. Earle J. Grippen, Supt., Endicott, N. Y. .... Feb. 28, 1928
ERIE COMMISSIONERS WATER WORKS. 701 French St., Erie, Pa. .... May 31, 1911
EVANSVILLE WATER WORKS. Evansville, Ind. .... May 7, 1906

FEDERAL LIGHT & TRACTION CO. 52 William St., New York, N. Y. .... Mar. 8, 1920
FLINT, MICH. Board of Water Commissioners, 509 Harrison St., Flint, Mich. .... Nov. 18, 1925
FOND DU LAC, MICH. City Water Department, L. P. Peeke, Superintendent, Fond Du Lac, Wisc. .... May 22, 1919
FORT COLLINS, COLORADO .... Mar. 16, 1926

GANANOQUE WATER WORKS COMMISSION. H. D. Rogers, Supt. Gananoque, Ont., Canada .... Mar. 16, 1927
GENERAL INSPECTION BUREAU. Lock Drawer 1746, Minneapolis, Minn .... Feb. 9, 1924
*GLENDALE, CALIF. Public Service Department, Peter Diederich, Supt., 575 Broadway, Glendale, Calif. .... Dec. 24, 1914
GLEN RIDGE WATER DEPARTMENT. A. F. Eschenfelder, Glen Ridge, N. J. .... Oct. 27, 1922
*GLENS FALLS BOARD OF WATER COMMISSIONERS. Glens Falls, N. Y. .... Oct. 24, 1918
G. V. GRACE & CO. G. Vincent Grace, 34 Pine St., New York, N. Y. .... Oct. 22, 1926
GRAND RAPIDS DEPARTMENT OF PUBLIC SERVICE. Grand Rapids, Mich. .... Feb. 14, 1913

Great Falls Water Dept. Great Falls, Montana........ Jan. 31, 1925
Greeley, Colo. M. Seaman, Water Supt., Greeley, Colo... Apr. 30, 1926
Green Bay Water Dept. James Church, Supt., Green Bay, Wis.................... Nov. 3, 1914
Griffin Light, Water & Sewerage Dept. Griffin, Georgia. Feb. 16, 1924
Grimsby, Ont. Water Commission, W. B. Smith, Chief Engineer & Supt., Grimsby, Ont., Can.................. Feb. 23, 1927
*Guelph, Ont. H. S. Nicklin, City Engineer, City Hall, Guelph, Ont., Canada.............................. Mar. 25, 1924
Gulf States Utilities Co. Louisiana Division, Lake Charles, La.. Apr. 29, 1910
*Guntersville Water Works. J. L. McIntyre, Supt., Guntersville, Ala.. Feb. 25, 1927

*Honolulu City and County, Department of Public Works. Kapiolani Building, Honolulu, T. H.......... Aug. 20, 1927
Hopkinsville Water Co. Hopkinsville, Ky............ Apr. 23, 1915
Hot Springs Water Co. Hot Springs, Ark................ Mar. 23, 1920

Idaho Surveying & Rating Bureau. P. O. Box 1059, Boise, Idaho.. Feb. 9, 1924
Ilion Board of Water Commissioners. Ilion, N. Y... Mar. 31, 1924
Illinois Inspection Bureau. 108 E. Ohio Street, Chicago, Ill.. Jan. 30, 1924
*Indiana State Board of Health, Water & Sewage Department. Lewis S. Finch, Director, Indianapolis, Ind.... June 15, 1926
*Interstate Public Service Co. New Albany, Ind......... Feb. 10, 1910
Ironwood Water Dept. Dow I. Sears, Ironwood, Mich.... May 17, 1920

Johnson City Water Dept. Arthur J. Merrill, Supt., Johnson City, N. Y.. Sept. 30, 1925

Kansas City, Mo. Director of the Water Dept., City Hall, Kansas City, Mo.................................... Feb. 8, 1915
Kelso Water Dept. A. L. Minard, Water Commissioner, Kelso, Wash... Jan. 17, 1928
Kennebec Water Dist.. Trustees. George K. Boutelle, Treasr., Waterville, Maine.................................... May 12, 1912
*Kentucky State Board of Health. F. C. Dugan, Dctr. Bur. San. Eng., 532 W. Main St. Louisville, Ky........ Feb. 5, 1915
Kentucky Utilities Co.. 1350 Starks Bldg., Louisville, Ky. Feb. 13, 1905
Kitchener Water Commission. Kitchener, Canada......... Feb. 17, 1920
*Knoxville Water Dept. City Hall Park Building, Knoxville, Tenn.. May 23, 1923

LaJunta, City of, Colorado.................................. Sept. 18, 1926
*Lake Forest Water Department. J. C. McNicol, Mgr., City Hall, Lake Forest, Ill................................ May 24, 1927
Lanett Cotton Mill. M. R. Wallis, West Point, Georgia... Mar. 1, 1924
*Lawrence, Kans. Engineering Department, C. T. Hough, City Engr. & Wtr. Supt., City Hall, Lawrence, Kansas Feb. 17, 1927
Leamington, Ontario, Canada, Corporation of Town of... May 30, 1925
Lewistown-Reedsville Water Co. Lewistown, Pa......... May 14, 1922
Lincoln City Water & Ltg. Dept. City Hall, Lincoln, Neb... Mar. 6, 1919
Lockport Board of Water Commissioners. Lockport, N. Y... Apr. 9, 1924

London, Canada, Public Utilities Commission.......... Apr. 9, 1909
Los Angeles, Calif. William Mulholland, Chf. Engr., Bureau of Water Works & Supply, Box 497, Los Angeles, Calif.......... Apr. 18, 1910
Los Angeles Water Service Co. J. L. Munson, Pres., 214 E. 96th St., Los Angeles, Calif.......... Oct. 27, 1925
Louisville Water Co. 435 So. Third St., Louisville, Ky..... Apr. 9, 1909
Loveland, Colorado, City of.......... Apr. 13, 1926

*Madera, Calif. Municipal Water Works, O. C. Owens, Supt., City Hall, Madera, Calif.......... June 17, 1926
Mahoning Valley Water Co. Struthers, Ohio.......... July 26, 1916
*Malmo Byggnadskontor. Alfred Jerden, Chf. Engr., Malmo, Sweden.......... July 23, 1921
Marion Water Co. George Whysall, Treas. and Gen. Mgr., Marion, Ohio.......... March 3, 1917
Massillon Water Supply Co. Watson A. Dark, Supt., Massillon, O.......... June 8, 1921
Meigs Water Co. C. M. Herminy, Gen. Mgr., Middleport, Ohio.......... Feb. 23, 1924
Memphis, Tenn. Board of Water Commissioners, James Sheahan, Gen. Supt., Memphis, Tenn.......... Apr. 2, 1909
*Merritton, Ont. Water Works Department, Public Utilities Commission, Merritton, Ont., Canada.......... June 17, 1926
Metropolitan Bd. Water Supply and Sewage. 341 Pitt St., Sydney, N. S. W., Australia.......... Aug. 31, 1909
Middletown Water Works. G. Allen Schaefer, Middletown, Conn.......... June 8, 1921
*Midland Public Utilities Comm. P. O. Box 548, Midland, Ont., Canada.......... Mar. 16, 1927
Mill Valley, Calif. H. C. Symonds, 147 Monte Vista Ave.......... Nov. 15, 1926
Millville Water Co. Millville, N. J.......... Jan. 11, 1916
Minneapolis Committee on Water Works. Wm. R. Young, Registrar, Minneapolis, Minn.......... June 17, 1920
Moline Water Department, City Hall, Moline, Ill.......... Jan. 29, 1916
*Montclair Bureau of Water Supply. Montclair, New Jersey.......... Apr. 27, 1925
Mt. Gilead Water, Light, Heat & Power Co., Mt. Gilead, Morrow Co., Ohio.......... Mar. 3, 1917
Mount Holly Water Co. Mount Holly, N. J.......... Apr. 30, 1924
Municipal Water Co. of Illinois. C. B. Shapker, President, 115 W. Adams St., Chicago, Ill.......... May 28, 1926
Muscatine Water Trustees. Muscatine, I.......... May 9, 1921

Negociado de Acueductosy, Alcantarillado. Secretaria de Obras Publicas, Havana, Cuba.......... Apr. 10, 1926
*New Jersey Dept. Conservation and Development. H. T. Critchlow, H. E., State House, Trenton, N. J.......... Jan. 26, 1922
New Jersey Water Co. 610 Station Ave., Haddon Heights, N. J.......... Jan. 6, 1927
*New Mexico Power Co. Santa Fe, N. Mex.......... Mar. 12, 1924
New Rochelle Water Co. 514 Main St., New Rochelle, N. Y.......... Jan. 6, 1927
North Dakota State Regulatory Department. R. O. Baird, Box 653, Bismarck, N. Dak.......... Jan. 19, 1926
North Jersey District Water Supply Comm. 20 Clinton Street, Newark, N. J.......... May 26, 1925

Northampton Consolidated Water Co. 102 So. 3rd St., Easton, Pa. .... Dec. 5, 1915
*Norton, Va. Water Dept., E. H. Ruehl, Mgr., Norton, Va. Jan. 10, 1925

Obras Sanitarias de la Nacion. Direccion Tecnica, Charcas 1840, Buenos Aires, A. R. .... Jan. 1, 1926
Obras Sanitarias of Entre Rios. Alberto F. Laurencena, President of Directory, Parana, A. R. .... Apr. 21, 1928
Ohio Inspection Bureau. Hartman Bldg., Columbus, Ohio. Jan. 30, 1924
Omaha, Nebr. Metropolitan Utilities District, Utilities Bldg., Harney at Eighteenth St., Omaha, Nebr. .... Apr. 28, 1912
Oswego Department of Water. Oswego, N. Y. .... June 1, 1921
*Owego Water Works Co. Owego, N. Y. .... Apr. 16, 1914

Pacific Water Co. S. E. Stern, Pres., 211 Second Ave., San Mateo, Calif. .... Oct. 29, 1926
Pasadena Water Dept. S. B. Morris, Chief Engineer, City Hall, Civic Center, Room 319, Pasadena, Calif. .... Oct. 14, 1924
Pennichuck Water Works. 11 High St., Nashua, N. H. .... Oct. 30, 1914
Pennsylvania State Water Corp. Reeves J. Newsom, Pres. 114 So. Front St., Milton, Pa. .... May 26, 1927
*Peoples Arizona Gas & Elec. Corp. P. O. Box 1159, Bisbee, Ariz. .... Sept. 8, 1924
Peoria Water Works Co. Peoria, Ill. .... Jan. 6, 1927
Peterborough, Ont. R. L. Dobbin, Waterworks Supt., 622 George St., Peterborough, Ont., Can. .... May 2, 1911
Pontiac, Mich. Dept. of Water Supply, G. D. Kennedy, Civil Engr., Pontiac, Mich. .... June 6, 1927
Portland Dept. of Public Utilities. Room 302, City Hall, Portland, Ore. .... Dec. 17, 1917
Potlatch Lumber Co. W. D. Humiston, Potlatch, Ida. Apr. 12, 1928
Poughkeepsie Board of Public Works. Water Department, Poughkeepsie, N. Y. .... Dec. 11, 1912
Providence, R. I. Water Maintenance Dept. City Hall, Providence, R. I. .... Oct. 9, 1924

Quincy Water Works Commission. 314 Maine St., Quincy, Ill. .... Apr. 4, 1927

Reading Bureau of Water. Room 209, City Hall, Reading, Pa. .... Mar. 20, 1916
Regina, Sask., Waterworks Department. City Hall, Regina, Sask., Canada. .... Apr. 4, 1924
*Riverside, Calif. Water Department .... July 22, 1926
Roanoke Water Works Co. Francis W. Collins, Cons. Engr., 452 Lexington Ave., New York, N. Y. .... Dec. 3, 1904
Rome. Department of Public Works, Bureau of Water, Rome, N. Y. .... Apr. 25, 1922

Saginaw Water Dept. Saginaw, Mich. .... Apr. 12, 1904
*St. Mary's Ont., Board of Water, Light & Heat Comn., Box 333, St. Marys Ont., Canada. .... Nov. 3, 1919
*St. Thomas, Ont. Colonel A. F. McLachlin, F.C.I.C., Ross Street, St. Thomas, Ont., Canada. .... Apr. 11, 1909
Salina Water Department. H. L. Brown, Supt., Salina, Kansas .... Feb. 17, 1927
*Salt Lake City Water Dept. H. K. Burton, Supt., Salt Lake City, Utah .... Feb. 17, 1920

San Jose Water Works. H. S. Kittredge, Pres., 374 W. Santa Clara St., San Jose, Cal........ Apr. 21, 1913
*Santa Monica, Calif. Water Department, City Hall, Santa Monica, Calif........ June 5, 1926
Scranton Gas and Water Co. 135 Jefferson Ave., Scranton, Pa........ June 3, 1912
Sea Breeze & Vicinity Wtr. Comn. Henry Fleig, Sect., Point Pleasant, Monroe Co., N. Y........ Feb. 23, 1920
Seattle Water Dept. W. B. Severyns, Supt., County-City Bldg., Seattle, Wash........ July 23, 1928
Sheboygan Board of Water Comnrs. City Hall, Sheboygan, Wis........ June 21, 1920
Shenandoah Commissioners of Water Works. Shenandoah, Pennsylvania........ May 19, 1924
Shenango Valley Water Co. 24 So. Dock St., Sharon, Pa. Apr. 10, 1922
Sherrill-Kenwood Water Commission. Stephen R. Leonard, Chairman, Kenwood, Oneida, N. Y........ Apr. 24, 1921
*Sioux Falls Water Works. R. Rees, Supt., Sioux Falls, S. Dak........ May 24, 1927
*Spokane, Wash. Alex. Lindsay, Superintendent Water Division, Room 302, City Hall, Spokane, Wash........ Apr. 5, 1912
Suburban Water Co. of Allegheny County. Verona, Pa..... Apr. 10, 1909
Sumpwams Water Works Co. J. C. Robbins, Pres., Babylon, N. Y........ June 15, 1926
Sweetwater Water Company. National City, Calif........ June 15, 1926
Syracuse Bureau of Water. Syracuse, N. Y........ Jan. 16, 1923

Tallassee Power Co. Badin, N. C........ Nov. 15, 1924
Texas-Louisiana Power Co. Fort Worth Club Bldg., Fort Worth, Tex........ Sept. 30, 1928
Toronto, Ohio, Board of Public Affairs. J. B. Thompson, Supt., Toronto, Ohio........ Feb. 23, 1924
Totowa, Borough of. Totowa, N. J........ Oct. 20, 1920
Trenton Water Works. Trenton, N. J........ May 8, 1909
Trotter Water Co. C. L. Farson, Supt., P. O. Box 308, Uniontown, Pa........ July 26, 1921
Troy Bureau of Water. William Luby, Troy, N. Y........ May 28, 1924
Truckee River Power Co. Reno, Nev........ Feb. 4, 1913

Urban Water Supply Co. Maurice & Borden Ave., Maspeth, L. I........ Oct. 20, 1912
Utrechtsche Waterleiding. Maatschappij, Utrecht, 15 Predikheerenkerkhof, Holland........ Nov. 9, 1922

Vallejo City Water Dept. J. L. Cunningham, Clerk, City Hall, Vallejo, Calif........ June 11, 1924

Waco Water Works. 617 Washington Ave., Waco, Texas... Apr. 16, 1910
Wahiawa Water Co., Ltd. Wahiawa, Oahu, T. H........ Apr. 20, 1923
*Watertown Water Works. Watertown, N. Y........ June 8, 1909
Welland, Ont., Board of Water Commission. L. Rochar, Welland, Ont., Canada........ May 7, 1920
Wenatchee Water Dept. Fred J. Sharkey, Supt., Wenatchee, Wash........ Jan. 20, 1928
West Newton Water Co. West Newton, Pa........ May 24, 1922
*West Virginia Water Service Co. H. M. Cogan, Genl. Mgr., Charleston, W. Va........ Sept. 4, 1911

WESTERN NEW YORK WATER CO. 11 Niagara St., Buffalo, N. Y.	Apr. 15, 1913
*WHITBY, ONT., PUBLIC UTILITY COMMISSION. George W. P. Every, Supt., Municipal Waterworks Dept., Whitby, Ont., Canada.	Feb. 23, 1924
WHITE DEER MOUNTAIN WATER CO. 114 So. Front St., Milton, Pa.	May 5, 1914
WHITE PLAINS DEPT. OF PUBLIC WORKS. William I. Collyer, Water Supt., White Plains, N. Y.	July 31, 1916
WHITTIER, CALIF. M. R. Bower, City Water Superintendent, City Hall, Whittier, Calif.	Dec. 16, 1926
WILLIAMSPORT WATER CO. 330 Pine St., Williamsport, Pa.	Apr. 15, 1907
WINDSOR ONT., WATER COMMISSIONERS. Windsor, Ont.	Feb. 19, 1923
*WINNETKA, ILL., VILLAGE OF	June 21, 1920
WINONA BOARD OF MUNICIPAL WORKS. Winona, Minnesota	Dec. 11, 1922

ASSOCIATE MEMBERS

ALLIS-CHALMERS MFG. Co. Milwaukee, Wis.	June 24, 1905
AMBURSEN CONSTRUCTION Co., INC. Grand Central Terminal Bldg., New York, N. Y.	Jan. 29, 1921
AMERICAN BRASS Co., THE. Sales Dept., Waterbury, Conn.	Aug. 10, 1922
AMERICAN CAST IRON PIPE Co. P. O. Boxes 151–152, Birmingham, Ala.	July 18, 1907
"AMERICAN CITY." 443 Fourth Ave., New York, N. Y.	May 25, 1918
AMERICAN FOUNDRY & MFG. Co. 10th, 11th, Hebert and Wright Sts., St. Louis, Mo.	May 12, 1908
AMERICAN MACHINE & FOUNDRY Co. J. D. McCarthy Adv. Mgr., 5502–5524 Second Ave., Brooklyn, N. Y.	Feb. 8, 1928
AMERICAN ROLLING MILL Co. R. C. Beam, Development Dept., Sales Div. Middletown, Ohio	Jan. 31, 1927
AMERICAN SEAMLESS TUBE CORPORATION OF CALIFORNIA. 710 Petroleum Securities Bldg., Los Angeles, Calif.	Sept. 12, 1927
AMERICAN STEEL & WIRE Co. Chemical & Color Dept., 208 South LaSalle St., Chicago, Ill.	June 24, 1903
AMERICAN WATER SOFTENER Co. Lehigh Ave. & Fourth St., Philadelphia, Pa.	July 14, 1923
AMERICAN WELL WORKS, THE. Aurora, Illinois.	Mar. 21, 1923
ARNOLD, HOFFMAN & Co., INC. 18th Floor, 350 Madison Ave., New York, N. Y.	Nov. 21, 1913
ART CONCRETE WORKS. Mfrs. Meter Boxes, P. O. Box 417, Pasadena, Cal.	Dec. 13, 1920
ASPHALTO-CONCRETE CORP. 1440 Broadway, New York, N. Y.	June 6, 1927
AUTOMATIC CONE VALVE Co. 165 W. Wacker Drive, Chicago, Ill.	Mar. 13, 1925
AUTOMATIC PRIMER Co. F. H. Bradford, Pres., 111 W. Washington St., Chicago, Ill.	Apr. 4, 1924
BABCOCK & WILCOX Co. J. B. Romer, Chemist, Bayonne, N. J.	May 28, 1924
BADGER METER MFG. Co. 841–7 Thirtieth St., Milwaukee, Wis.	June 8, 1904
BARBER-GREENE Co. Aurora, Ill.	Jan. 26, 1926
BAYARD, M.L. 20th St. & Indiana Ave., Philadelphia, Pa.	Mar. 31, 1922
BEALL PIPE & TANK CORP. John S. Beall, Pres., Portland, Ore.	Apr. 12, 1928
BELMONT SMELTING & REFINING WORKS. 330 Belmont Ave., Brooklyn, N. Y.	Dec. 13, 1928
BENT CONCRETE PIPE Co. 419 Grosse Bldg., Los Angeles, Calif.	Oct. 18, 1928
BIGGS BOILER WORKS COMPANY. Mr. F. G. Sherbondy, Sect.-Treas., Bank & Williams Streets, Akron, Ohio.	Apr. 28, 1925
BIRCH MANUFACTURING Co. 1521–1523 Sedgwick St., Chicago, Ill.	May 11, 1916
BOURBON COPPER & BRASS WORKS Co. 618 E. Front St., Cincinnati, Ohio.	Apr. 17, 1884
BOWLER FOUNDRY Co. 1688 Columbus Road, Cleveland, Ohio.	July 6, 1922

Buckeye Traction Ditcher Co. C. D. Royce, Sales & Avd. Mgr., Findlay, Ohio	May 26, 1920
Buffalo Meter Co. 2917 Main St., Buffalo, N. Y.	June 27, 1905
Builders Iron Foundry, 9 Codding St., Providence, R. I.	June 18, 1901
Burroughs Adding Machine Co. A. S. Trew, Public Utilities Sale, Second Boulevard, Detroit, Mich.	Mar. 30, 1926
Byers, A. M., Co. 235 Water St., Pittsburgh, Pa.	June 15, 1921
California Corrugated Culvert Company. 5th & Parker Sts., West Berkeley, Calif.	Aug. 24, 1927
California Meter Co. 687–89 So. Clarance St., Los Angeles, Calif.	June 6, 1927
"Canadian Engineer." Church & Court Sts., Toronto, Ont., Can.	May 31, 1916
Canadian Salt Co., Ltd. Windsor, Ont. Canada	May 5, 1928
Cement Gun Construction Company. 58 Sutter St., San Francisco, Calif.	Oct. 13, 1926
Cement Lined Pipe Co. 591 Washington St., Lynn, Mass.	May 28, 1924
Central Foundry Co. Graybar Bldg., 420 Lexington Ave., New York, N. Y.	June 24, 1903
Chapman Valve Mfg. Co. Indian Orchard, Mass.	Apr. 16, 1884
Chicago Bridge & Iron Works., 37 W. Van Buren St., Chicago, Ill.	June 15, 1908
Chicago Chemical Co. 6216 W. 66th Place, Chicago, Ill.	June 6, 1927
Clark, H. W., Co. Box 563, Mattoon, Ill.	May 12, 1908
Clow, J. B., & Sons, Harrison & Franklin Sts., Chicago, Ill.	Apr. 27, 1885
Coffin Valve Co., Neponset, Mass.	May 21, 1922
Cohoes Rolling Mill Co. Canvass & Cortland Sts., Cohoes, N. Y.	Jan. 2, 1924
Coldwell-Wilcox Co. Newburgh, N. Y.	Apr. 17, 1914
Colorado Fuel & Iron Co. Denver, Colo.	June 7, 1897
Columbian Iron Works. Chattanooga, Tenn.	Apr. 4, 1910
Cook, A. D., Inc. Manufacturer of Deep Well Pumps & Strainers, Lawrenceburg, Ind.	June 14, 1914
Copper & Brass Research Assoc. Wm. G. Schneider, 25 Broadway, New York, N. Y.	Aug. 28, 1923
Crane Company. A. M. Houser, Engineer of Product, 836 S. Michigan Ave. Chicago, Ill.	Jan. 25, 1926
Crane, Theron I. Vice Pres., Talbot Non-Corrosive Linings Co., 1114 Widener Bldg., Philadelphia, Pa.	Mar. 27, 1926
Darling Valve & Man'fg. Co. Williamsport, Penna.	May 12, 1908
Dayton-Dowd Co. Quincy, Ill.	July 5, 1922
Dearborn Chemical Co. 310 So. Michigan Ave., Chicago, Ill.	June 6, 1927
De Laval Steam Turbine Co. H. L. Watson, Sales Mgr., Trenton, N. J.	Nov. 23, 1917
Donaldson Iron Co. Emaus, Lehigh Co., Pa.	Nov. 23, 1917
The Dorr Co., Inc. 247 Park Ave., New York, N. Y.	June 1, 1927
Dravo-Doyle Co. J. D. Berg, Vice-Pres., Diamond Bank Bldg., Pittsburgh, Pa.	May 12, 1914
Drummond, McCall & Co., Ltd. Toronto, Ont., Canada	Mar. 5, 1921
du Pont de Nemours, E. I. & Co. R. H. Dufault, Sales Mgr., Acid & Heavy Chemical Division, 3500 Grays Ferry Road, Philadelphia, Pa.	May 12, 1908
East Jersey Pipe Co. 7 Dey St., New York, N. Y.	July 10, 1906
Eddy Valve Co. Waterford, N. Y.	June 26, 1886

EDSON MANUFACTURING CORP. 375 Broadway, Boston '11', Mass. .... Mar. 21, 1923
ELECTRO BLEACHING GAS CO. 9 E. 41st St., New York, N. Y. .... Apr. 2, 1913
ELECTROZONE CORP. 5949 Grand Central Terminal Bldg., New York, N. Y. .... Dec. 29, 1927
"ENGINEERING & CONTRACTING." 221 E. 20th St., Chicago, Ill. .... May 13, 1918
"ENGINEERING NEWS-RECORD." 10th Ave. at 36th St., New York, N. Y. .... May 31, 1918
FAIRBANKS COMPANY. E. F. Ryan, Works Mgr., Glenwood Ave., Binghampton, N. Y. .... Mar. 30, 1926
FAIRBANKS, MORSE & CO. Research Division, Chicago, Ill... Mar. 23, 1925
FARNAN BRASS WORKS CO. 1104 Center St., Cleveland, Ohio. May 18, 1892
FEDERAL METER CORP., East Orange, N. J. .... May 23, 1923
FLEISCHMANN CO. Peekskill, N. Y. .... June 15, 1922
FORD METER BOX CO. Wabash. Ind. .... May 12, 1908
FORNI MANUFACTURING CO. 1377 62nd St., Oakland, Cal.... Aug. 28, 1924
FOX, JOHN, & CO. 233 Broadway, New York City, N. Y. .... June 8 1909

GAMON METER CO. Newark, N. J. .... May 19. 1920
GENERAL CHEMICAL CO. 300 W. Adams St., Chicago, Ill. .... June 11, 1902
GENERAL ELECTRIC CO. Mr. Lee F. Adams, Industrial Engineering Dept., Schenectady, N. Y. .... June 1, 1921
GEORGIA-LOUISIANA CORP. East Point, Ga .... July 31, 1928
GIANT MANUFACTURING CO. Council Bluffs, Iowa.......... Jan. 5, 1925
GILLESPIE, T. A., CO. 7 Dey St., New York, N. Y. .... June 7, 1904
GLAMORGAN PIPE & FOUNDRY CO. Lynchburg, Va. .... Nov. 6, 1907
GLAUBER BRASS MFG. CO. Platt Ave. & East 79th St., Cleveland, Ohio .... May 13, 1914
GREENBERG'S SONS, M. Fire Hydrant & Valve Mfrs., 765 Folsom St., at Alice St., San Francisco, Cal. .... Sept. 30, 1924
GRIFFIN FDY. & MFG CO. M. N. Griffin, Pres., Rome, Ga.. .. June 30, 1926
GRINNELL CO., INC. P. O. Box 336, Charlotte, N. C. .... May 17, 1923
GURLEY, W. & L. E. 514 Fulton St., Troy, N. Y. .... Apr. 16, 1919

HANKIN, FRANCIS, & CO., LTD. 598-604 Union Ave., Montreal, Canada .... June 19, 1920
HANKS CO., FRED W. Fred W. Hanks, Mgr., 10624 St. Clair Ave., Cleveland, Ohio .... June 5, 1926
HARDESTY MFG. CO., R. 31st & Blake Sts., Denver, Colo.... Mar. 31, 1925
HAYS MFG. CO. Erie, Pa .... Mar. 15, 1882
HENDRIE & BOLTHOFF MFG. & SUPPLY CO. James S. Smith, 1635 Seventeenth St., Denver, Colo. .... Mar. 22, 1926
HERSEY MFG. CO. South Boston, Mass. .... July 14, 1887
HOOKER ELECTROCHEMICAL CO. G. F. Reale, 25 Pine St., New York, N. Y. .... July 7, 1920
HUNGERFORD & TERRY, INC. Clayton, N. J. .... Dec. 31, 1926
HYDRAULIC DEVELOPMENT CO. 296 Boylston St., Boston, Mass. .... May 12, 1925
INGERSOLL, RAND CO. 11 Broadway, New York City .... Oct. 31, 1922
INTERNATIONAL FILTER CO. 333 W. 25th Place, Chicago, Ill. Nov. 3, 1915
INTERSTATE MACHINERY & SUPPLY CO. 1006-8-10 Douglas St., Omaha, Nebr. .... May 31, 1927

BYRON JACKSON PUMP MFG. CO. West Berkeley, Cal. .... Sept. 30, 1924
JANNSEN, NEWMAN C. 3101 L. C. Smith Bldg., Seattle, Wash.. Mar. 28, 1928
JENKINS BROS., LTD. 103 St. Remi St., Montreal, Canada... May 20, 1920

JOHNSON, EDWARD E., INC. 2304 Long Ave., St. Paul, Minn..	May 17, 1922
JONES, JAMES, CO. W. B. Jones, Secy., 201 Leroy St., Los Angeles, Cal.	Oct. 20, 1921
KALBFLEISCH CORPORATION. 200 Fifth Ave., New York, N. Y.	June 8, 1906
KELLY WELL CO. 112½ E. Third St., Grand Island, Nebr.	Jan. 7, 1924
HERBERT KENNEDY & CO., INC. Sales Agents, Pont-a-Mousson Pipe, 475 Fifth Ave., New York, N. Y.	Sept. 8, 1928
KENNEDY VALVE MFG. CO. M. E. Kennedy, Treas., Elmira, N. Y.	Mar. 24, 1911
KEYSTONE DRILLER COMPANY. Will R. Cook, Mgr., Pump Department, Beaver Falls, Pa.	June 1, 1927
KINGSBURY MACHINE WORKS, INC. 4324 Tackawanna St., Frankford, Philadelphia, Pa.	June 1, 1927
LA MOTTE CHEMICAL PRODUCTS CO. McCormick Bldg., Baltimore, Md.	May 14, 1926
LAYNE AND BOWLER CO. Memphis, Tenn.	June 5, 1916
LEAD LINED IRON PIPE CO., THE. Wakefield, Mass.	Oct. 5, 1898
LEADITE COMPANY, INC., THE. Land Title Building, Philadelphia, Pa.	Feb. 10, 1910
LINDE AIR PRODUCTS CO. R. W. Boggs, 30 E. 42nd St., New York, N. Y.	Mar. 31, 1928
LOCK JOINT PIPE CO. Box 21, Ampere, N. J.	Oct. 5, 1915
LUDLOW VALVE MFG. CO. Troy, N. Y.	Mar. 5, 1882
LYNCHBURG FOUNDRY CO. Lynchburg, Va.	June 6, 1916
McCLOSKEY TORCH CO. 3343 Collingwood Ave., Toledo, Ohio.	June 6, 1927
McEVERLAST, INC. 111 W. 7th St., Los Angeles, Calif.	Nov. 27, 1926
McWANE CAST IRON PIPE CO. Birmingham, Ala.	Apr. 23, 1923
MABBS HYDRAULIC PACKING CO. 431 S. Dearborn St., Chicago, Ill.	May 7, 1923
MACHINERY PIPE & SUPPLY CO. 200—9th, San Diego, Calif.	Nov. 15, 1926
MACLEAN, HUGH C., PUBLICATIONS, LTD. Pblr. Trade & Tech. Jls., 347 Adelaide St. W., Toronto, Ont., Canada.	June 2, 1920
MATHIESON ALKALI WORKS, INC. 250 Park Ave., New York, N. Y.	Mar. 16, 1920
MICHIGAN VALVE & FOUNDRY CO. 3631 Parkinson Ave., Detroit, Mich.	June 7, 1919
MIRACLE CONSTRUCTION CO. 1604 Dale St., San Diego, Calif..	June 11, 1928
MISSISSIPPI LIME & MATERIAL CO. Mr. C. C. Schmoeller, Sales Mgr., Alton, Illinois.	June 20, 1925
MODERN IRON WORKS. Quincy, Ill.	June 27, 1905
MONTAGUE PIPE & STEEL CO. 803 Hobart Building, San Francisco, Calif.	Dec. 31, 1922
MOORE BROTHERS. 415 Virginia Ave., Elkhart, Ind.	Nov. 4, 1926
MORRIS, I. P., CORP. Richmond & Norris Sts., Philadelphia, Pa.	Oct. 21, 1927
MORRIS MACHINE WKS. Baldwinsville, N. Y.	July 31, 1923
MUELLER BRASS CO. O. B. Mueller, Port Huron, Mich.	June 6, 1927
MUELLER CO. Decatur, Ill.	Mar. 15, 1882
MULTIPLEX MFG. CO. Multiplex Bldg.. Berwick, Pa.	May 7, 1916
MURRAY IRON WORKS CO. Burlington, Iowa.	Mar. 6, 1923
NATIONAL ALUMINATE CORP. 6216 W. 66th Place, Chicago, Ill.	June 21, 1926
NATIONAL CAST IRON PIPE CO. E. E. Linthicum, Pres., Birmingham, Ala.	May 17, 1916
NATIONAL IRON CORPN., LTD. Cherry St., Toronto, Ont., Canada.	Oct. 22, 1921

National Meter Co. 299 Broadway, New York, N. Y.	Mar. 15, 1882
National Tube Co. W. L. Schaeffer, 1902 Frick Bldg., Pittsburgh, Pa.	May 18, 1921
National Water Main Cleaning Co. 50 Church St., New York, N. Y.	July 10, 1906
Nelson, Jos. E., & Sons. Contractors, 3240 S. Michigan Ave., Chicago, Ill.	Sept. 7, 1919
Neptune Meter Co. 50 East 42nd St., New York, N. Y.	Aug. 22, 1894
Northern Gravel Co. G. H. Boynton, Pres., American Savings Bk. Bldg., Muscatine, Iowa	Jan. 31, 1927
Ohio Drilling Co. Thos. O. Poe, Massillon, Ohio	June 17, 1926
Ohio Varnish Company. Mr. J. P. Deery, 8709 Kinsman Road, Cleveland, Ohio	May 29, 1925
Oswego Pipe Co. 205 Porter Bldg., Portland, Ore.	Dec. 8, 1927
Ottawa Silica Co. P. S. McDougall, Gen. Mgr., Ottawa, Ill.	Apr. 27, 1927
Pacific Pump Works. 350 Bickett Street, Huntington Park, Calif.	Aug. 8, 1927
Pacific States Cast Iron Pipe Co. P. O. Box 18, Provo, Utah	Oct. 31, 1927
Parker Appliance Co. 10320 Berea Rd., Cleveland, Ohio	May 11, 1927
Parsons Company. Newton, Iowa	Dec. 10, 1925
Parsons, Klapp, Brickerhoff & Douglas. Consulting Engineers, 84 Pine St., New York, N. Y.	July 26, 1922
Peerless Pump Co. P. O. Box 493, Massillon, Ohio	June 6, 1927
Pennsylvania Salt Mfg. Co. Widener Building, Philadelphia, Pa.	June 24, 1903
Penstock Construction Co. F. M. Strecker, President, Sharon, Pa.	Nov. 25, 1925
Permutit Co. 440 Fourth Ave., New York, N. Y.	Mar. 11, 1914
Philadelphia Suburban Water Co. 762 Lancaster Ave., Bryn Mawr, Pa.	May 1, 1909
Phoenix Meter Co. 5906 Amboy Rd., Princes Bay, S. I., N. Y.	May 11, 1927
Pitometer Co. 50 Church St., New York, N. Y.	July 10, 1906
Pittsburgh-Des Moines Steel Co. Pittsburgh, Pa.	Apr. 14, 1914
Pittsburgh Equitable Meter Co. Wilkinsburg Branch P. O., Pittsburgh, Pa.	June 15, 1898
Pittsburgh Testing Laboratory. P. O. Box 1115, Pittsburgh, Pa.	May 8, 1915
Pollard, Joseph G., Co., Inc. 142 Raymond St., Brooklyn, N. Y.	Apr. 30, 1926
Pomona Mfg. Co. 206 E. Commercial St., Pomona, Calif.	May 24, 1927
Portland Cement Association. 33 W. Grand Ave., Chicago, Ill.	Oct. 23, 1917
Price Brothers Co. H. D. Knight, Chief Engr., 1012 Harries Bldg., Dayton, Ohio	Sept. 22, 1928
"Public Works." 243 West 39th St., New York, N. Y.	May 25, 1918
R. U. V. Co. 7 Burritt Ave., South Norwalk, Conn.	June 6, 1917
Raymond Equipment Co. P. O. Box 1613, 1017 Piedmont Road, Charleston, W. Va.	Jan. 11, 1926
Rensselaer Valve Co. Troy, N. Y.	May 12, 1890
Republic Brass Co. 1617-33 E. 45th St., Cleveland, Ohio	Mar. 31, 1928
Republic Flow Meters Co. 2240 Diversey Parkway, Chicago, Ill.	Jan. 10, 1927

Rex Tapping Machine Co. L. M. Biddle, 919 Sonoma St., Vallejo, Calif.	Oct. 27, 1925
Rich Steel Products Company. 3855 Santa Fe Ave., Los Angeles, Calif.	Sept. 26, 1927
Riter Conley Co. Box 939, Pittsburgh, Pa.	June 11, 1924
Roberts Filter Mfg. Co. Darby, Philadelphia, Pa.	Mar. 23, 1910
Rome Brass & Copper Co. Rome, N. Y.	Aug. 31, 1928
Ross Valve Mfg. Co., Inc. Oakwood Ave., Troy, N. Y.	Apr. 18, 1891
S. E. T. Valve & Hydrant Co. 50 Church St., New York, N. Y.	Apr. 14, 1924
Sanitation Corp. Graybar Bldg., Grand Central Terminal, New York, N. Y.	Apr. 27, 1915
Savage, W. J., Co. Knoxville, Tenn.	May 31, 1919
Scofield Engineering Co. 1324 Commercial Trust Bldg., Philadelphia, Pa.	June 7, 1921
Shand & Jurs Co. 917 Carlton St., Berkeley, Calif.	Apr. 12, 1928
Simplex Valve & Meter Co. 5722 Race St., Philadelphia, Pa.	May 14, 1914
Sims Pump Valve Co. 2 Rector St., New York, N. Y.	Mar. 23, 1922
Sirch, C. W. Sirch Filters, Suite 300–301 Lankersheim Bldg., Los Angeles, Calif.	Sept. 25, 1923
Smith, A. P. Mfg. Co. East Orange, N. J.	June 7, 1897
Sparling, R. W. Manufacturer of Water Measuring Equipment, 945 North Main St., Los Angeles, Calif.	Nov. 10, 1925
Steel Tank & Pipe Co. of Calif. 1100 Fourth St., Berkeley, Calif.	Aug. 23, 1926
Sterling Pump Works, Inc. 646 S. California St., Stockton, Calif.	Jan. 19, 1926
Stone & Webster, Inc. Dana M. Wood, 147 Milk Street, Boston, Mass.	May 29, 1925
Sullivan Machinery Co. 122 S. Michigan Ave., Chicago, Ill.	Mar. 31, 1915
Sydnor Pump & Well Co., Inc. Thos. G. Sydnor, Pres., Richmond, Va.	Dec. 13, 1924
Taylor, W. P., Co. 218 Ellicott Square, Buffalo, N. Y.	Mar. 15, 1882
Thompson, William H., Co., Inc. Water Main Cleaning Contrs., 501 Linwood Ave., Buffalo, N. Y.	Jan. 10, 1925
Thomson-Adriance, Inc. 253 Broadway, New York, N. Y.	Apr. 17, 1928
Thomson Meter Co. 50 E. 42nd St., New York, N. Y.	Apr. 15, 1891
Traverse City Iron Works. Box 67, Traverse City, Mich.	Apr. 29, 1924
Union Water Meter Co. 33 Hermon St., Worcester, Mass.	Mar. 15, 1882
United Casting Company. 824 Wilson St., Los Angeles, Calif.	Sept. 7, 1926
United Lead Co., 111 Broadway, New York, N. Y.	May 12, 1908
United States Cast Iron Pipe & Foundry Co., 1421 Chestnut St., Philadelphia, Pa.	June 11, 1892
Van Gilder Water Meter Co. Chester & Grant Aves., Pleasantville, N. J.	Mar. 31, 1924
Victaulic Company of America, 26 Broadway, New York, N. Y.	Apr. 13, 1926
Virginia Mach. & Well Co., Inc. Chas. F. Cole, Pres., 1319 E. Main St., Richmond, Va.	Apr. 20, 1926
Vogt Brothers Mfg. Company. 1402 West Main Street, Louisville, Ky.	May 12, 1925

WAILES DOVE-HERMISTON CORP. 17 Battery Place, New York, N. Y.	Mar. 13, 1925
WALLACE & TIERNAN CO., INC. Box 178, Newark, N. J.	Apr. 23, 1915
WARREN FOUNDRY & PIPE CO. 11 Broadway, New York, N. Y.	Mar. 4, 1911
"WATER WORKS ENGINEERING." 225 West 34th St., New York, N. Y.	June 28, 1919
WATER WORKS EQUIPMENT CO. 50 Church St., Rooms 1950–51, New York, N. Y.	July 10 1906
WATER WORKS SUPPLY CO. 208 Sharon Bldg., San Francisco, Calif.	Apr. 12, 1928
WATEROUS FIRE ENGINE WORKS. 80 E. Filmore Avenue, St. Paul, Minn.	May 20, 1925
WATERPROOF PAINT CO. Eugene R. Oden, Lankershim, Calif.	May 24, 1927
WESTERN CONCRETE PIPE CO. P. O. Box 355, Los Angeles, Calif.	Oct. 25, 1926
WESTERN CONSTRUCTION NEWS, INC. 114 Sansome St., San Francisco, Calif.	Apr. 6, 1928
WESTERN PIPE & STEEL CO., OF CALIF. 444 Market St., San Francisco, Calif.	Aug. 13, 1924
WESTERN WELL WORKS, INC. 522 West Santa Clara St., San Jose, Calif.	Aug. 8, 1927
WITT-HUMPHREY STEEL CO. Greensburg, Pa.	June 17, 1926
WOOD, R. D., & CO 400 Chestnut St., Philadelphia, Pa.	Apr. 16, 1884
WORTHINGTON PUMP & MACH'Y CORP. 115 Broadway, New York, N. Y.	June 18, 1901

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Talladega: Dougherty
Tuscaloosa: Abbott

CORPORATE

Birmingham: Alabama Power Co.
Guntersville: Guntersville Water Works

ASSOCIATE

Birmingham: American Cast Iron Pipe Co., McWane Cast Iron Pipe Co., National Cast Iron Pipe Co.

ARIZONA

Active 5; Corporate 1; Total 6

ACTIVE

Ajo: DuMoulin
Flagstaff: Marshall
Prescott: Shaw
Tucson: Rider, Whitacre

CORPORATE

Bisbee: Peoples Arizona Gas & Elec. Corp.

ARKANSAS

Active 3; Corporate 3, Total 6

ACTIVE

Fort Smith: Vaughn, Ward
Jonesboro: Christy

CORPORATE

Helena: Arkansas Utilities Co.
Hot Springs: Hot Springs Water Co.
Pine Bluff: Arkansas Power & Light Co.

CALIFORNIA

Honorary 1; Active 169; Corporate 19; Associate 30; Total 219

HONORARY

Los Angeles: Mulholland

ACTIVE

Alhambra: Downer, Goble
Arcadia: Lee
Bakersfield: Dillon
Berkeley: De Costa, Foreman, Hyde, Langelier, Moullet, Reinke, Rhodes, Stava
Beverly Hills: Gerhart
Burlingame: Henderson, Schuck
Calexico: Perhab
Campbell: Hyde
Carlsbad: Fraser
Compton: Parrish
Corona: Case
Encinitas: Brown
Fresno: Barnum, Jackson, Leovitt
Gardena: Sevier
Glendora: Warren
Hanford: Isaac, Johns
Hayward: Smalley
Huntington Park: Mohr
La Habra: Launer
Lindsay: Trauger
Long Beach: Shaw
Los Angeles: Anderson, Barnard, Bayley, Beeson, Bowen, Brooks, Cates, Chamberlain, Derby, Dodge, Finkle, Goudey, Hurlbut, Koster, Lawton, Luippold, Moore, Nicholson, Palmer, Rowe, Shonerd, Slater, Smith, Stone, Taylor, Volk, Wilson
Los Banos: Delaney
Lynwood: Cummings
Manteca: Jones
Martinez: Gaul
Marysville: Belcher
Merced: Casad
Monrovia: Gierlich
Monterey Park: Oberholtzer
National City: Rice
Newport Beach: Cundiff, Patterson

Oakland: Allen, Davis, Farrell, Gillespie, Hawley, Klaus, Magerstadt, Reinhardt, Stewart, Wilhelm
Orland: Wright
Oroville: Davis
Pacific Grove: Olmstead
Pasadena: Allin, Jones, Morris
Petaluma: Ellsworth
Pico: Robinson
Placentia: Lee
Redding: Steinhauer
Redondo Beach: Gram, Rice, Tomlinson
Riverside: Chase
Sacramento: Hoskinson, Prugh, Stevenson
St. Helena: Gertsen
San Bernardino: Starke
San Bruno: Jorgensen
San Diego: Albin, Cowles, Ervast, Lovell, Symons, Wueste
San Francisco: Abbott, Andrews, Badger, Barker, Bovard, Bragg, Cashmore, Chisholm, De Josez, DeMartini, Elliott, Ellis, Flaa, Hammerly, Harris, Hommon, Hunter, Kempkey, Kennedy, Lee, Loveland, MacKall, Martindale, McCarty, McMillan, O'Shaughnessy, Perry, Porter, Pracy, Randlett, Schuyler, Sharon, Suters
San Gabriel: Kline
San Jose: Ford, Green, Kittredge, Relph
San Rafael: Burt, Everette, Longland, Peters, Prentice
Santa Barbara: Trace, Wyant
Santa Clara: Dixon
Santa Cruz: Tait
Santa Monica: Elrod
Santa Paula: Giacomazzi
Sonoma: Emparan
South Pasadena: Mudge, Roen
Stanford University: Marx
Stockton: Brown, Griffin
Tulare: Berryhill
Turlock: Brown
Tustin: Wray
Vernon: McCurdy
Watsonville: Kitchen
Whittier: McLaren
Willets: Morris
Willows: Snedeker
Yreka: Thomas

CORPORATE

Antioch: City of Antioch
Beverly Hills: Water Department
Burbank: Public Service Department
Glendale: Public Service Department
Los Angeles: Bureau of Water Works and Supply, Conservative Water Co., Los Angeles Water Service Co.
Madera: Municipal Water Works
Mill Valley: H. C. Symonds
National City: Sweetwater Water Co.
Oakland: East Bay Water Co.
Pasadena: Water Department
Riverside: Water Department
San Francisco: Benicia Water Co.
San Jose: San Jose Water Works
San Mateo: Pacific Water Co.
Santa Monica: Water Department
Vallejo: Water Department
Whittier: Water Department

ASSOCIATE

Berkeley: Shand & Jurs Co., Steel Tank & Pipe of Calif.
Huntington Park: Pacific Pump Works.
Lankershim: Waterproof Paint Co.
Los Angeles: American Seamless Tube Corp. of Calif., Bent Concrete Pipe Co., Calif. Meter Co., James Jones Co., McEverlast, Inc., Rich Steel Products Co., C. W. Sirch, R. W. Sparling, United Casting Co., Western Concrete Pipe Co.
Oakland: Forni Manufacturing Co.
Pasadena: Art Concrete Works
Pomona: The Pomona Mfg. Co.
San Diego: Machinery Pipe & Supply Co., Miracle Construction Co.
San Francisco: Cement Gun Construction Co., M. Greenberg's Sons, Montague Pipe & Steel Co., Water Works Supply Co., Western Construction News, Inc., Western Pipe & Steel Co. of Calif.
San Jose: Western Well Works, Inc.
Stockton: Sterling Pump Works, Inc.
Vallejo: Rex Tapping Machine Co.
West Berkeley: Byron Jackson Pump Mfg. Co., California Corrugated Culvert Co.

COLORADO

Active 28; Corporate 6; Associate 3; Total 37

ACTIVE

Boulder: Poe
Brighton: Petersen
Colorado Springs: McReynolds, Truman
Denver: Gross, Kepner, Lasley, Leaf, Leahy, Lowther, Mars, Jr.,

McLaughlin, Mulligan, Ristine, Jr., Robinson, Sumner, Turre, Vail, Warner, Wilson
Gunnison: Keenan
Hugo: Van Arsdale
Leadville: Sharp
Montrose: Smith
Pueblo: Porter, Stone, Wagner
Rocky Ford: Strouse

CORPORATE

Boulder: Water Department
Canon City: Water Department
Fort Collins: City of Fort Collins
Greeley: City of Greeley
La Junta: City of La Junta
Loveland: City of Loveland

ASSOCIATE

Denver: Colorado Fuel & Iron Co., The R. Hardesty Manufacturing Co., Hendrie & Bolthoff Manufacturing & Supply Co.

CONNECTICUT

Active 22; Corporate 3; Associate 2; Total 27

ACTIVE

Ansonia: Davis
Bridgeport: Senior
Bristol: Lourie
Danbury: Raymond
East Hartford: Walsh
Greenwich: Putnam, Willson
Hartford: Berry, Newlands, Peck, Saville, Scott
New Canaan: Schweppe
New Haven: Gaillard, Glynne, Hill, Minor, Winslow
Southington: MacKenzie
Stamford: Ketcham
Thompsonville: Schwabe
Torrington: Travis

CORPORATE

Derby: Birmingham Water Co.
Hartford: State Department of Health
Middletown: Middletown Water Works

ASSOCIATE

South Norwalk: The R. U. V. Co.
Waterbury: The American Brass Co.

DELAWARE

Active 7; Total 7

ACTIVE

Dover: Beckett
Wilmington: Butz, Sr., Draper, Feeney, Hoopes, Jr., Van Trump, Wills

DISTRICT OF COLUMBIA

Active 13; Total 13

ACTIVE

Washington: Burt, Collins, Curtis, Dorsey, Hardy, Howell, Kav, Lauter, Macqueen, Miller, Tarbett, Thompson, Van Doren

FLORIDA

Active 55; Total 55

ACTIVE

Bradenton: Van Camp
Clearwater: Schwabel
Daytona Beach: Main, Tippins
Fort Lauderdale: Cannon, Keis, Solomon
Fort Pierce: Smith
Gainesville: Barnes, Brown
Hollywood: Jones, Stewart
Homestead: Davis
Jacksonville: Eastwood, Filby, Kolb, Parker, Simons, Jr., Tyler, Weaver
Kissimmee: Buckels
Lakeland: Brown
Lake Worth: Wertz, Wright
Melbourne: Bennett
Miami: Hyman
Mulberry: Madison
Opa Locka: Rowe, Russell
Orlando: Michaels, Norris, Rhynus Wechter
Palatka: Cauthorn
Palmetto: Mixson
St. Augustine: Center, Gray
St. Petersburg: Lane
Sanford: Duane
Sarasota: Brumby
Stuart: DeMoya
Tallahassee: Gunter
Tampa: Hamilton, Humphreys, Jones, Lyles, McFarland, Squires
Titusville: Wilson
Vero Beach: Damerow
West Palm Beach: Chinn, Reynolds, Rice, Robinson
Winter Park: Georgia

GEORGIA

Honorary 1; Active 18; Corporate 2; Associate 2; Total 23

HONORARY

Atlanta: Clayton

ACTIVE

Atlanta: Grimes, Hall, Kite, Neville, Singleton, Smith, Titshaw, Weir, Wiedeman, Wilcox
Augusta: Hunter, Smith
Columbus: Darrow, Richards, Smalshaf
Newnan: Passolt
Thomasville: Pringle
Valdosta: Saurbrey

CORPORATE

Griffin: Light, Water & Sewerage Department
West Point: Lanett Cotton Mill

ASSOCIATE

East Point: Georgia-Louisiana Corp.
Rome: Griffin Foundry & Manufacturing Co.

IDAHO

Active 5; Corporate 2; Total 7

ACTIVE

Boise: Smith, Turner
Idaho Falls: Wilson
Lewiston: Hughes
Pocatello: Rainey

CORPORATE

Boise: Idaho Surveying & Rating Bureau
Potlatch: Potlatch Lumber Co.

ILLINOIS

Honorary 2; Active 153; Corporate 8; Associate 26; Total 189

HONORARY

Chicago: Keeler
Quincy: Bull

ACTIVE

Alton: Miller
Aurora: Barclay, Dean, Willett
Bloomington: Woltman
Blue Island: Hammond
Cairo: Roos
Carbondale: Dyhrkopp, Gill
Champaign: Amsbary
Chicago: Allen, Alvord, Bachmann, Barron, Bauereisen, Baylis, Berhman, Bemis, Birdsall, Brensley, Burdick, Christman, Cole, Coughlan, Crane, DeBerard, DeLeuw, Dorsey, Eddy, Enander, Engel, Fager, Fink, French, Friend, Fulkman, Gayton, Gerstein, Goldsmith, Gordon, Gorman, Greeley, Green, Greer, Groner, Hancock, Hanley, Hansen, Harris, Hendricks, Hickox, Holmes, Holway, Horne, Horstmann, Jordan, Kivell, Knowles, Kramer, McClenahan, Marner, Marshall, Massey, Mathews, Matteson, Maxwell, Merckel, Mohlman, Moore, Moseley, Munn, Noble, Olson, Parsons, Pearse, Prindle, Putnam, Ramey, Rasch, Rathbun, Reynolds, Richardson, Ruchhoft, Schmid, Jr., Shaw, Frank R., Shaw, Walter A, Sherman, Shields, Skinner, Speer, Jr., Stanley, Suhr, Tanner, Tonney, Versulius, Vogelback, Williams, Wolfe
Danville: Ely, Symons
Decatur: Carrick, Hatfield, Greenfield, Warren
Des Plaines: Wells
Dixon: Hawley
East St. Louis: Horner
Elmhurst: Crockett
Evanston: Polk
Freeport: Hutchins
Galva: Lundberg
Glencoe: Young
Harvey: Rossman
Hillview: Stoldt
Hinsdale: Menold
Jacksonville: Potter, Swanson
Kankakee: Huse
LaGrange: Howson
Lake Forest: Gibbs
Marseilles: Hahn
Mattoon: Clark, Rue
Maywood: Warnecke
Moline: Jahns
Monmouth: Boruff
Morrison: Green
Mt. Carmel: Barnhard
Murphysboro: Tennant

Newton: Holt
Oak Park: Davidson, Meyers
Pana: Stanfield
Pekin: Lautz
Peoria: Baker, Crozier, Morgan, Ringness
Quincy: Gelston
Rock Island: Murrin
South Chicago: Chamberlin
Springfield: Ferguson, Reid, Sabin, Spaulding
Sterling: MacDonald
Streator: Huggans
Taylorville: Dappert
Urbana: Babbitt, Boruff, Buswell, Enger, Fleming, Habermeyer, Mavis, Talbot
Waukegan: Miller
Wheaton: Stickney
Zion: Craig

CORPORATE

Chicago: Illinois Inspection Bureau, Municipal Water Co. of Illinois
Lake Forest: Water Department
Moline: Water Department
Peoria: Peoria Water Works Co.
Quincy: Water Works Commission
Springfield: Central Illinois Public Service Co.
Winnetka: Village of Winnetka

ASSOCIATE

Alton: Mississippi Lime & Material Co.
Aurora: The American Well Works, Barber-Greene Co.
Chicago: American Steel & Wire Co., Automatic Cone Valve Co., Automatic Primer Co., Birch Manufacturing Co., Chicago Bridge & Iron Works, Chicago Chemical Co., J. B. Clow & Sons, Crane Co., Dearborn Chemical Co., Engineering & Contracting, Fairbanks, Morse & Co., General Chemical Co., Mabbs Hydraulic Packing Co., National Aluminate Corp., Jos. E. Nelson & Sons, Portland Cement Association, Republic Flow Meters Co., Sullivan Machinery Co.
Decatur: Mueller Co.
Mattoon: H. W. Clark Co.
Ottawa: Ottawa Silica Co.
Quincy: Dayton-Dowd Co., Modern Iron Works

INDIANA

Honorary 1; Active 49; Corporate 3; Associate 3; Total 56

HONORARY

Terre Haute: Gwinn

ACTIVE

Columbus: Harger
Elkhart: Stephenson
Fort Wayne: Lennon, Waldrop
Frankfort: Marvin
Gary: Luscombe
Greencastle: Reeves
Greenfield: Wolfe
Hammond: Bowers, Partridge, Schonert
Indianapolis: Brossman, Calvert, Cruger, Diggs, Garman, Hurd, Jeup (Bernard H.), Jeup (B. J. T.), Jordan (Frank C.), Jordan (Harry E.), Mabee, Mauch, Moore, (J. W.), Moore, (Russell B.), Morse, Newcomer, Schwier, Winkle
Kokomo: Stradling
La Porte: Foutz
Marion: Van Cleave
Mt. Vernon: Ploch
Muncie: Stewart
Newcastle: Younce
Princeton: Caton, Joplin
Richmond: Dill
South Bend: Dish, McCaffery
Sullivan: Kerlin
Tell City: Weisenberger
Terre Haute: Durbin
Valparaiso: Agar, Bradley
Vincennes: Watts
Wabash: Klare
Washington: Jones
Whiting: Bartuska

CORPORATE

Evansville: Water Works
Indianapolis: Water & Sewage Department
New Albany: Interstate Public Service Co.

ASSOCIATE

Elkhart: Moore Brothers
Lawrenceburg: A. D. Cook, Inc.
Wabash: Fort Meter Box Co.

IOWA

Honorary 1; Active 48; Corporate 3; Associate 4; Total 56

HONORARY

Davenport: Donahue

ACTIVE

Ames: Buchanan, Jenks, Levine, Murphy
Bettendorf: Schneider
Boone: Nelson
Burlington: Lawlor
Carroll: Badley
Cedar Rapids: Bates, Blomquist
Centerville: Alexander
Clarinda: Ehrhart
Clinton: Chase
Council Bluffs: Hansen, Jensen, Myrtue
Davenport: Healey, Henderson
Des Moines: Conrath, Corcoran, Denman, Higgins, Maffitt (Dale L.), Maffitt (Howard C.), Tenny, Thorpe, Wieters
Fort Dodge: Bird, Pray
Fort Madison: Kearns
Harlan: Cox
Iowa City: Bartow, Hinman, Jr., Hostetler, Keller, Waterman
Marion: Toms
Marshalltown: Pederson
Mason City: Crofoot
Muscatine: Molis
Oskaloosa: Hawkins
Ottumwa: Brown
Sioux City: Carlin, Smith, Sutherland
Waterloo: Hendry, Shoemaker
Webster City: Currie

CORPORATE

Creston: Taxpayers Municipal Water Works
Dubuque: Dubuque City Water Works
Muscatine: Water Trustees

ASSOCIATE

Burlington: Murray Iron Works Co.
Council Bluffs: Giant Manufacturing Co.
Muscatine: Northern Gravel Co.
Newton: The Parsons Co.

KANSAS

Active 13; Corporate 3; Total 16

ACTIVE

Abilene: Sutton
Atchison: Chisham
Chanute: Lawrence
Emporia: Kunz
Eureka: Huntington
Kansas City: Barclay, Mangun
Lawrence: Boyce
Manhattan: Ulrich
Salina: Paulette
Topeka: Stewart
Wichita: Kelley
Winfield: Welfelt

CORPORATE

Emporia: Water Department
Lawrence: Engineering Department
Salina: Water Department

KENTUCKY

Active 29; Corporate 5; Associate 1; Total 35

ACTIVE

Ashland: Patton
Bowling Green: Ennis
Catlettsburg: Patton
Covington: Kingsley
Frankfort: Griffin
Georgetown: Allen
Hazard: Ihrig
Henderson: Overstreet
Lawrenceburg: Madison
Lexington: Bell, Cramer (Hugh R.), Cramer (W. S.), Gillig, Pinnell
Louisville: Chambers, Clemens, Long, Lovejoy, McGonigale, Parker, Peabody, Stover
Mayfield: Orr
Maysville: Cochran
Mt. Sterling: Blevins
Owensboro: Watson
Paducah: Burnett
Richmond: Dougherty
Winchester: Attersall

CORPORATE

Ashland: Water Commission
Hopkinsville: Hopkinsville Water Co.

Louisville: State Board of Health, Kentucky Utilities Co., Louisville Water Co.

ASSOCIATE

Louisville: Vogt Brothers Manufacturing Co.

LOUISIANA

Honorary 1; Active 10; Corporate 2; Total 13

HONORARY

New Orleans: Earl

ACTIVE

Hammond: Mentz
Monroe: Fletcher
New Orleans: Earl, Eastwood, Fowler, Grant, O'Neill, Porter
Shreveport: Amiss, Mayo

CORPORATE

Baton Rouge: Baton Rouge Water Works Co.
Lake Charles: Gulf States Utilities Co.

MAINE

Active 11; Corporate 1; Total 12

ACTIVE

Augusta: Campbell
Bangor: Powell
Northeast Harbor: Mullikin
Ogunquit: Phillips
Orono: Everett
Portland: Coburn, Graham, West (Geo. F.), West (Vernon F.)
Rockland: McAlary
Waterville: Thompson

CORPORATE

Waterville: Trustees Kennebec Water District

MARYLAND

Active 36; Associate 1; Total 37

ACTIVE

Annapolis: Munroe
Baltimore: Adams, Armstrong, Biser, Blohm, Di Domenico, Ellis, Flack, Goldstein, Gregory, Hopkins, Keefer, Megraw, Powell, Requardt, Strohmeyer, Walden, Warren, Whitman, Wolf, Wolman
Chevy Chase: Maury
Cumberland: Fowler
Frederick: Crum
Hagerstown: Cannen, Ferguson, Heard
Hyattsville: Devilbiss, Hall, Hechmer, Morse, Shaw
Linthicum Heights: Diggs, Jr.
Riverdale: Owings
Salisbury: Dryden
Towson: Jones

ASSOCIATE

Baltimore: La Motte Chemical Products Co.

MASSACHUSETTS

Honorary 2; Active 59; Associate 9; Total 70

HONORARY

Holyoke: Tighe
Lowell: Thomas

ACTIVE

Boston: Barbour, Chase, Clark, Curtis, Eddy, Fales, Finneran, French, Goodnough, Horne, Houser, Howard, Killam, McInnes, Marston, Sherman, Skinner, Taber, Wentworth (Franklin H.), Wentworth (John P.), Weston, Wheeler, Williams, Winsor
Brockton: Kingman
Brookline: Hale
Cambridge: Fair, Good, Griffin, Hatch, Whipple
Concord: Robinson
Danvers: Esty
Fairhaven: Gidley
Fall River: Guiney
Framingham Centre: Macksey
Holyoke: Gear
Jamaica Plain: Hough
Lawrence: Hale
Lowell: Reynolds, Safford
Medford: Dwyer
Melrose: Emerson
Milton: Heffernan
New Bedford: Chase, Drake, Taylor
Newton Centre: Gilcreas
Newtonville: Burnham
Reading: Taber
Somerset: Eagan
Southbridge: Abbott
Springfield: Lochridge
Waban: Symonds
Ware: Merrill
Wellesley Hills: Adams

West Somerville: Lacount
Worcester: Batchelder, Hoy, Kiernan

ASSOCIATE

Boston: Edson Manufacturing Corp., Hydraulic Development Co., Stone & Webster, Inc.
Indian Orchard: Chapman Valve Manufacturing Co.
Lynn: Cement Lined Pipe Co.
Neponset: Coffin Valve Co.
South Boston: Hersey Manufacturing Co.
Wakefield: The Lead Lined Iron Pipe Co.
Worcester: Union Water Meter Co.

MICHIGAN

Active 60; Corporate 7; Associate 4; Total 71

ACTIVE

Alma: Hartmann
Ann Arbor: Ayres, Decker, Hoad, Holland, McNamee, Williams
Cadillac: Webb
Clawson: Cookingham
Coldwater: McQueen
Detroit: Bird, Blessed, Dow, Dunham, Ellis, Fenkell, Gerardy, Grobbel, Hardin, Hinchman, Hubbell, Lenhardt, Majeske, Mayo, Morrill, Norton, Orton, Outzen, Rudd, Stephenson, Wallace, Wyckoff
E. Lansing: Woods
Fordson: McCarthy
Grand Rapids: Billings, Hamilton, Sperry, Vogelback
Highland Park: Bolton, Hoot, Whitsit
Holland: Champion
Iron Mountain: Croll, Senseman
Jackson: Best, England, Hatch
Kalamazoo: Libby, Norman
Lansing: Hackett
Ludington: Williams
Marquette: Johnston
Monroe: Weaver
Mt. Clemens: Keils
Pontiac: Monroe
Port Huron: Cascadden, Naumann, Sterosky
Rochester: Jackson
Saginaw: Eymer

CORPORATE

Ann Arbor: Water Works Commission
Bay City: Water Works Department
Flint: Board of Water Commissioners
Grand Rapids: Department of Public Service
Ironwood: Water Department
Pontiac: Department of Water Supply
Saginaw: Water Department

ASSOCIATE

Detroit: Burroughs Adding Machine Co., Michigan Valve & Foundry Co.
Port Huron: Mueller Brass Co.
Traverse City: Traverse City Iron Works

MINNESOTA

Honorary 1; Active 43; Corporate 3; Associate 2; Total 49

HONORARY

St. Paul: Caulfield

ACTIVE

Austin: Todd
Chisholm: Sullivan
Crookston: Peterson
Duluth: Corine, Foster, Kelly, Reed, Wilson
Fairmont: Basom
Faribault: Wilson
Fridley: Wilbur
Gilbert: Spitznagel
Hibbing: Forsberg
Lake City: Howe
Lakewood: Seligman
Minneapolis: Bass, Beal, Finch, Janzig, Jensen, Johnson, Lundell, McCulloh, Mellen, Moberg, Montank, Raab, Whittaker, Woodward, Young
Rochester: Schwarz
St. Cloud: Seibert
St. Paul: Crowley, Druar, Feist, Grime, Kelsey, McDonald, May, Routh, Sudheimer, Thuma
Virginia: Pruett

CORPORATE

Minneapolis: Committee on Water Works, General Inspection Bureau
Winona: Board of Municipal Works

ASSOCIATE

St. Paul: Edward E. Johnson, Inc., Fred A. Waterous

MISSISSIPPI

Active 3; Total 3

ACTIVE

Jackson: Fewell
Meridian: Slaughter
Winona: Johnson

MISSOURI

Active 54; Corporate 1; Associate 1; Total 56

ACTIVE

Hannibal: Wolfe
Independence: Gallagher
Jefferson City: Helmreich, Johnson, Peters
Kansas City: Archer, Bacharach, Baldwin, Black, Foreman, Gilkison, Haskins, Kiersted, Jr., Learned, McDonnell, Mullergren, Paulette, Pratt, Reynolds, Strang, Veatch, Jr., Whitmire
St. Joseph: Bodkin
St. Louis: Allgeyer, Black, Chivvis, Cutts, Day, Easterday, Ebeler, Flad, Fleming, Fuller, Graf, Henby, Jutz, Meyer, Monfort, Nelson, Nolte, Pritchard, Serkes, Skinker, Smith, Steinbruegge, Wall, Wesley, Wilcox
Savannah: Lauber
Sedalia: Andrews
Springfield: Gray, Pate
University City: Weir
West Plains: Britain

CORPORATE

Kansas City: Director of the Water Department

ASSOCIATE

St. Louis: American Foundry & Manufacturing Co.

MONTANA

Active 25; Corporate 2; Total 27

ACTIVE

Billings: Willett
Butte: Carroll, Plummer, Probst, Thomas
Chinook: Brandis
Choteau: Hall
Columbus: McClure
Deer Lodge: Coleman
Dillon: Holtz
Glendive: Hurdle
Havre: Sandquist
Helena: Foote, Nimmo
Kalispell: Lawrence, MacDonald
Lewistown: Schmit
Livingston: Cortese
Missoula: Christensen, Thane
Ronan: Odiet
Roundup: Quinnell
Superior: Horning
Troy: Hubbard
Whitefish: Bayha

CORPORATE

Anaconda: Water Works Department
Great Falls: Water Department

NEBRASKA

Active 9; Corporate 2; Associate 2; Total 13

ACTIVE

Lincoln: Erickson, Letton
Omaha: Armstrong, Barr, Bruce, Knouse, Leisen
Plattsmouth: Minor
Wilber: Diller

CORPORATE

Lincoln: Water and Lighting Department
Omaha: Metropolitan Utilities District

ASSOCIATE

Grand Island: Kelly Well Co.
Omaha: Interstate Machinery & Supply Co.

NEVADA

Active 2; Corporate 1; Total 3

ACTIVE

East Ely: Smith
Reno: Campbell

CORPORATE

Reno: The Truckee River Power Co.

NEW HAMPSHIRE

Active 3; Corporate 1; Total 4

ACTIVE

Concord: Howard, Storrs
Hanover: Marsden

CORPORATE

Nashua: Pennichuck Water Works

NEW JERSEY

Active 122; Corporate 11; Associate 9; Total 142

ACTIVE

Ampere: Holway, Longley
Arlington: Donnelly
Asbury Park: Bartley, White
Atlantic City: Van Gilder, Wigley
Bernardsville: Williamson
Bogota: Cowles
Boonton: Breitzke, Mallalieu
Bound Brook: Brush, Downes, Smith
Burlington: Buzby, Capron, Conard, Russell
Camden: Long, Smith, Vosbury
Cedar Grove: Goslau
Charlotteburg: Reilly
Clifton: Mahoney
Collingswood: Borden
East Orange: Halpin, McLaughlin, Roper, Snyder
Elizabeth: Booth, Buck, Faitoute, Mitchell, Newkirk, Radcliffe
Englewood: French
Franklin: Jenkins
Glen Rock: Towle
Hackensack: Noack
Haledon: Kapp, Jr.
Harrison: Matte
Haskell: Holdredge
Hoboken: Anderson
Jersey City: Corbin, Jewell, Louison, McEvoy, Mauzy, Tator, Van Keuren
Little Falls: Green
Lodi: McClellan
Long Branch: Herr
Merchantville: Rudderow
Millville: Buell
Montclair: Folwell, Knox
Moorestown: Bishop
Morristown: Hoffman
New Brunswick: Atkinson, Lendall, Morris
New Milford: Cowles, Spalding
Newark: Baldwin, Bank, Ely, Foulks, Judson, Mueller, Orchard, Pratt (Arthur H.), Pratt (Gilbert H.), Rosentreter, Scherer, Scholz, Sherman, Sherrerd, Woolley
Nutley: Cutler
Orange: Dodge, Luthy, Ruggles
Palisades: Miller
Passaic: Hopper, Knight,
Paterson: Cook, Cuddeback, Edwards, Harder, Ryle
Perth Amboy: Mason
Plainfield: Gavett
Pleasantville: Trumbore
Princeton: Eldridge
Rahway: Gibbons
Red Bank: Cadman, Keckler
Ridgewood: Bauman, Carr
Riverside: Port
Riverton: Buck
Short Hills: Kohout
South Orange: Smith
Summit: Bassett
Trenton: Brooks, Bugbee, Croft, Hartwell
Upper Montclair: Wilson
Weehawken: Alfke, Davies, Fricker, Lebold, Schlicht, Talbot
West Englewood: Wieghardt
West Orange: Fritz, Glannan, Wilson
Wildwood: Banks
Woodbridge: Mundy

CORPORATE

Dover: Water Commissioners
East Orange: Board of Water Commissioners
Glen Ridge: Water Department
Haddon Heights: New Jersey Water Co.
Millville: Millville Water Co.
Montclair: Bureau of Water Supply
Mount Holly: The Mount Holly Water Co.
Newark: North Jersey District Water Supply Commission
Totowa: Borough of Totowa
Trenton: New Jersey Department Conservation and Development, Trenton Water Works

ASSOCIATE

Ampere: Lock Joint Pipe Co.
Bayonne: The Babcock & Wilcox Co.
Clayton: Hungerford & Terry, Inc.
East Orange: The Federal Meter Corp., The A. P. Smith Manufacturing Co.
Newark: Gamon Meter Co., Wallace & Tiernan Co., Inc.
Pleasantville: Van Gilder Water Meter Co.
Trenton: DeLaval Steam Turbine Co.

NEW MEXICO

Active 2; Corporate 3; Total 5

ACTIVE

Cimarron: Alpers
Santa Fe: Fox

CORPORATE

Deming: Water Department
East Las Vegas: Agua Pura Co.
Santa Fe: New Mexico Power Co.

NEW YORK

Honorary 3; Active 295; Corporate 30; Associate 59; Total 387

HONORARY

New York: Herschel, Smith
Troy: Mason

ACTIVE

Albany: Bates, Cook, Cox, Holmquist, Horton, Prior, Slack, Suter Wachter, Wheeler, Willcomb
Amsterdam: Dwyer
Astoria: Culyer
Avon: Clark
Bay Shore: Clark, Fenn, Jr.
Binghampton: Gitchell, Hotchkiss
Briarcliff Manor: Manahan
Brooklyn: Aeryns, Armstrong, Bleistein,, Dowd, Flannery, Gaffney, Hale, Larmon, Woolnoug, Vertefeuille
Buffalo: Ames, Andrews, Bartram, Bassett (Charles K.), Bassett (Geo. B.), Boyle, Chambers, Diehl, Fitzgerald, Grotz, Huy, Reisweber, Roberts, Showell, Jr., Spire, Wagner
Canajoharie: Bullock
Canandaigua: Ellis
Corning: Drake
Cortland: Eginton, Peck
East Rochester: Babcock
Elmira: Jones
Elsmere: Bedell, Tiedeman
Fairport: Scarth
Far Rockaway: Bettes, Durland, Stearns
Flushing: Cook, Laase
Gloversville: Orr
Great Bend: McWilliams
Greenlawn: Sleeper
Haverstraw: Chapman
Hawthorne: King
Hempstead: Marshall, Stevens
Herkimer: Wood
Highbridge: Nelson
Highland: Schantz
Hudson Falls: Fasoli
Ilion: Trimble
Ithaca: Bishop, Carpenter, Chamot, Seery
Jackson Heights: Craig, Jr., Diven, Jr.
Katonah: Coffin
Kingston: Honness, Loughran
Larchmont: Foote, Hoffmaster
Le Roy: Palmer
Little Falls: Feeter
Long Island City: Ankener, Clark, Weaver
Lynbrook: Clark
Lyons: Zimmerlin
Malone: Van Deusen
Mamaroneck: Duffy, Nordmann
Manhasset: Hoag
Merrick: Spear
Middletown: Korschen, LaPolt
Mineola: Bowne
Mount Kiso: Sawin
Mount Vernon: Havill, Wolbert
Newark: Wright
Newburgh: Gilcrist
New Rochelle: Applebaum, Cranch, MacNamee, Reynolds, Jr.
New York: Baker, Baldwin, Ballou, Barns, Beck, Berry, Besselievre, Biggs, Jr., Blanchard, Blossom, Bogert, Booth, Bowe, Brush, Bull (Charles H.), Bull (Irving C.), Case, Chase, Chenery, Cleveland, Cleverdon, Clowes, Cole, Coulter, Cunningham, Darby, Dennett, Dodd, Donaldson, Dunham, Elliott, Enslow, Everett, Ewry, Ferguson, Freer, Fuertes, Fuller, Geehan, Gordon, Gould, Hansen, Harding, Jr., Hazen, Hendrick, Hibbard, Hill, Jr., Hoag, Hoagland, Hodgman, Hogan, Holbrook, Holdredge, Howland, Hutson, Jackson, Jacobs, Jacobsen, Johnson (Geo. A.), Johnson (R. K.), Jones (Allen A.), Jones (H. Seaver), Kemble, Kenzle, Kienle, Klein, Kriegsheim, Ledden, Luce, McClintock, McKay, Malcomson, Manahan, Marsh, Mendelsohn, Merriman, Meyerherm, Milholland, Newsom, Niesley, Norcom, Nuebling, O'Leary, Parker, Patitz, Pease, Phelps, Phillips, Pincus, Pirnie, Potter, Potts, Provost, Jr., Reinhard, Ridley, Sanborn, Scott, Siems, Spear, Stearns, Stewart, Tainter, Tribus, Tuttle, Van Gorder, Vermeule, Watt, Wells, Wiggin, Williamson, Wilson, Wood
Niagara Falls: Dignan, McCulloh, Perry, Robbins, Suitor

North Tarrytown: Helling
North Tonawanda: Batt
Norwich: Ames, Riley
Oneida: White
Oneonta: Lyon, Lyon (Mrs.)
Ossining: Bedell
Oswego: McCaffrey
Peekskill: Lockwood
Perry: Snyder
Port Chester: Cooney
Prattsville: Fifield
Rensselaer: Claflin
Rochester: Baker, Bliven (Geo. H.), Bliven (M. Harvey), Fisher, Goler, Hevenor, Hopkins, Kittredge, Lewis, Little, Lynch, Matthews, Miller, Prince, Russell, Skinner, Worthington
Scarsdale: Henshaw, Wyckoff
Schenectady: Devendorf, Erickson, Taylor
Southampton: Van Brunt
South Nyack: Kendall
Staten Island: Barnes
Syracuse: Booth, Daw, Keating, Palmer, Starbird, Stewart, Williams, Jr.
Tarrytown: Losee
Troy: Caird, Caldwell, Clifton, End, Knickerbacker
Utica: Allen, Dewey, Hodges, Hopkins, (Edwin W.) Hopkins, (Franklyn C.) Miles, Robertson
Valley Stream: Morlan
Voorheesville: Horton
Wappingers Falls: Beasley
Waterford: Yaxley
Watertown: Ackerman, Field
Wellsville: Rowe
White Plains: Mapes
Woodhaven: Bliven
Yonkers: Buhrendorf, Curran

CORPORATE

Auburn: Water Department
Babylon: Sumpwams Water Works Co.
Buffalo: Bureau of Water, Western New York Water Co.
Corning: Water Works
Elmhurst: Citizens Water Supply Co.
Elmira: Water Board
Endicott: Endicott Water Works Co.
Glens Falls: Board of Water Commissioners
Ilion: Board of Water Commissioners
Johnson City: Water Department
Kenwood: Sherril-Kenwood Water Commission
Lockport: Board of Water Commissioners
Lowville: Adirondack Water Works
Maspeth: Urban Water Supply Co.
New Rochelle: The New Rochelle Water Co.
New York: American Water Works & Electric Co., Inc., Community Water Service Co., Federal Light & Traction Co., G. V. Grace & Co., Roanoke Water Works Co.
Oswego: Department of Water
Owego: Owego Water Works
Point Pleasant: Sea Breeze & Vicinity Water Commission
Poughkeepsie: Board of Public Works
Rome: Department of Public Works
Syracuse: Bureau of Water
Troy: Bureau of Water
Watertown: Water Works
White Plains: Department of Public Works

ASSOCIATE

Baldwinsville: Morris Machine Works
Binghamton: The Fairbanks Co.
Brooklyn: American Machine & Foundry Co., Belmont Smelting & Refining Wks., Joseph C. Pollard Co., Inc.
Buffalo: Buffalo Meter Co., W. P. Taylor Co., William H. Thompson & Co., Inc.
Cohoes: Cohoes Rolling Mill Co.
Elmira: The Kennedy Valve Manufacturing Co.
Newburgh: Coldwell-Wilcox Co.
New York: Ambursen Construction Co., Inc., American City, Arnold, Hoffman & Co., Inc., Asphalto-Concrete Corp., The Central Foundry Co., Copper & Brass Research Assoc., The Dorr Company, Inc., East Jersey Pipe Co., Electro Bleaching Gas Co., Electrozone Corp., Engineering News-Record, John Fox & Co., T. A. Gillespie Co., Hooker Electrochemical Co., Ingersoll, Rand Co., International Filter Co., Kalbfleisch Corp., Herbert Kennedy Co., Inc., The Linde Air Products Co., Inc., The Mathieson Alkali Works, Inc., National Meter Co., National Water Main Cleaning Co., Neptune

Meter Co., Parsons, Klapp, Brickerhoff & Douglas, The Permutit Co., The Pitometer Co., Public Works, S. E. T. Valve & Hydrant Co., The Sanitation Corp., Sims Pump Valve Co., Thomson-Adriance, Inc., Thomson Meter Co., United Lead Co., Victaulic Company of America, Wailes, Dove-Hermiston Corp., Warren Foundry & Pipe Co., Water Works Engineering, Water Works Equipment Co., Worthington Pump & Machinery Corp.
Peekskill: The Fleischmann Co.
Schenectady: General Electric Co.
Princes Bay: Phoenix Meter Co.
Rome: Rome Brass & Copper Co.
Troy: W. & L. E. Gurley, Ludlow Valve Manufacturing Co., Rensselaer Valve Co., Ross Valve Manufacturing Co., Inc.
Waterford: Eddy Valve Co.

NORTH CAROLINA

Active 75; Corporate 1; Associate 1; Total 77

ACTIVE

Albemarle: Moore
Apex: Hobgood
Asheville: Burchard, Wilson, Wright
Badin: Lilly
Bessemer City: White
Cary: Heater
Chapel Hill: Baity, Ray, Jr., Saville
Charlotte: Bishop, Booker, Davis, Drane, Greenlee, Heyward, McConnell, Marshall, Mees, Myers, Vest
Concord: Fisher
Durham: Davis, Michie, Piatt, Suggs, White, Williams, Worth
Farmville: McAdams
Fayetteville: Shell
Fremont: Benton
Franklinton: Cooke
Gastonia: Rhyne, Struthers
Greensboro: Boyles, Lewis, Smedberg, True
Greenville: Swartz
Henderson: Bridgers
Hendersonville: Lampley
High Point: Dishner
Kings Mountain: Parsons
Lexington: Bullard
Lumberton: McNeil
Mebane: Michael
Mooresville: Fields
Morehead City: McCrea
Mount Airy: Absher
Mount Holly: Patterson
New Bern: Godfroy
Pinehurst: Pender
Raleigh: Bain, Kellogg, McLeod, Miller, Olsen, Trice, Whitener
Robersonville: Coburn
Rocky Mount: Lyon
Rutherfordton: Anderson
Salisbury: Craig
Southern Pines: Jarrett
Statesville: Cochran
Wake Forest: McKaughan
Waynesville: Logan
Wilmington: Lassiter, Maffitt
Wilson: Gladding
Winston-Salem: Ludlow
Zebulon: Finch, Pippin

CORPORATE

Badin: Tallassee Power Co.

ASSOCIATE

Charlotte: The Grinnell Co., Inc.

NORTH DAKOTA

Active 3; Corporate 1; Total 4

ACTIVE

Bismarck: Yegen
Fargo: Tarbell
Minot: Thomas

CORPORATE

Bismarck: Regulatory Department

OHIO

Active 92; Corporate 9; Associate 15; Total 116

ACTIVE

Akron: Barstow, Hibbs, Paul, Stringfellow
Barberton: Campion
Bucyrus: Lower
California: Bahlman
Canton: McClaskey, Ohliger
Cincinnati: Evans, Hill, Miller, Streeter, Theriault
Cleveland: Antweiler, Ellms, Farrell, Gascoigne, Habeshain, Havens, Jones, Lawrence, Levy, Linders, Marshall, Perkins, Quayle, Schmitt, Sheal, Siedle, Tolles, Watzl, Wright

Columbus: Bradbury, Burgess, Foulk, Groeniger, Hoover (Charles P.), Hoover (Clarence B.), Kimberly, Knox, Lathrope, Laux, Lawrence, McAlpine, Martin, Pierce, Prior, Sickel, Walker, Waring
Dayton: Arnold, Doten, Moorehouse, Prinz, Tatlock, Wight, Yackley
Dennison: Romig
Euclid: McCandless
Kent: Gettrust
Lima: Brower, Evans
Lorain: Brown, Humason
Marion: Browne
Medina: Fretter
Oberlin: Elder
Piqua: Montgomery
Shelby: Bricker
Steubenville: Scott
Struthers: Evans
Tiffin: Wetter
Toledo: Brown, Champe, Clark, Furman, Jones, Keller, Roberts, Schoonmaker
Warren: Inman, O'Connor
Washington C. H.: O'Neall
Xenia: Zell
Youngstown: Cornell, Dittoe, Dixon, Kinder, Reeder, Russell, Van Arnum

CORPORATE

Ashtabula: The Ashtabula Water Supply Co.
Columbus: Ohio Inspection Bureau
Marion: Marion Water Co.
Massillon: Massillon Water Supply Co.
Middleport: The Meigs Water Co.
Mount Gilead: Mount Gilead Water, Light, Heat & Power Co.
Struthers: Mahoning Valley Water Co.
Toronto: Board of Public Affairs
Wilmington: The Dayton Power & Light Co.

ASSOCIATE

Akron: The Biggs Boiler Works Co.
Cincinnati: Bourbon Copper & Brass Works Co.
Cleveland: The Bowler Foundry Co., The Farnan Brass Works Co., Glauber Brass Manufacturing Co., The Fred W. Hanks Co., The Ohio Varnish Co., The Parker Appliance Co., The Republic Brass Co.
Dayton: Price Bros. Co.
Findlay: Buckeye Traction Ditcher Co.
Massillon: The Ohio Drilling Co., Peerless Pump Co.
Middletown: The American Rolling Mill Co.
Toledo: McCloskey Torch Co.

OKLAHOMA

Active 11; Total 11

ACTIVE

Bartlesville: Perkins
Chickasha: McBurnett
Oklahoma City: Bretz, Rupp
Ponca City: Crow
Stillwater: Smith
Tulsa: Cecil, Dones, Ginter, Karl, Shaner

OREGON

Active 17; Corporate 1; Associate, 2; Total 20

ACTIVE

Eugene: McClain
Hillsboro: Gates, Wiley
Jefferson: Mars
Klamath Falls: Kendall
Marshfield: Corey
Portland: Benedict, Ehle, Helwick, Johnson, Koon, Morrow, Murray, Thompson, Wagner, Willard
Salem: Beebe

CORPORATE

Portland: Department of Public Utilities

ASSOCIATE

Portland: Beall Pipe & Tank Corp., Oswego Pipe Co.

PENNSYLVANIA

Active 166; Corporate 18; Associate 28; Total 212

ACTIVE

Allentown: Schnabel
Altoona: Campbell
Ambler: Hibschman
Aspinwall: Drake
Beaver Falls: Burnie
Bethlehem: Shipman
Bristol: Roberts, Jr.
Brookville: Sayer
Bryn Mawr: Davis, McCurdy
Carlisle: Waggoner

Catasauqua: Muser
Chambersburg: Mowrey
Chester: Calhoun, Lamey
Chinchilla: Salisbury
Clearfield: Hess, Nevling
Columbia: Meyers
Cooperstown: Crawford
Corry: Brown
Downingtown: Wagner
Easton: Rader
Erie: Dunwoody, Engh, Gensheimer
Ford City: Wintgens
Glenside: Friel
Greensburg: Smith, Spencer
Harrisburg: Avery, Craig, Daniels, Flentje, Gannett, Glace, Mark, Moses, Scheffer, Siebert, Stevenson, Weed (Ellsworth S.), Weed (Frederick H.)
Hazleton: McGeehin
Indiana: Lyle
Jersey Shore: Kinter
Johnstown: Crichton, Hagins, Kunkle, Watkins
Lancaster: Axe, Goodell, Ruth, Will
Langhorne: Stompler
Lansdowne: Jenkins
Lansford: Roads, Jr.
Lehighton: West
McKeesport: Trax
McKees Rocks: Beech
Meadville: Ellsworth, Siebert
Monongahela: Nutt
Natrona: Coffey, Knight
New Kensington: Griffiths
Norristown: Russell
North East: Leet
Philadelphia: Bartlett, Bean, Becker, Blaisdell, Blew, Boardman, Corin, Easby, Jr., Emerson, Jr., Fishtein, Freeburn, Greer, Gushee, Harder, Haydock, Jenne, Landreth, Lawrence, Ledoux, McCaleb, McCrudden, Miller, Nichols, Riebel, Saunders, Schaut, Siddons, Simpson, Stein, Stone, Suttle, Swaab, Thomas, Tolson, Van Loan, Welsford, Wertz, Yoder
Philipsburg: Pharaoh
Pittsburgh: Bankson, Baton, Chester, Douglass, Foote, Harshbarger, Hopkins, Hudson, Hutton, Knowles Laboon, Lanpher, Leopold, Mansfield, Mellon, Rice (Cyrus Wm.), Rice (John M.), Rockwell, Scharff, Simpson, Speller, Weidlein
Pottsville: Beisel, Clayton
Punxsutawney: Startzell
Reading: Felix, Mast, Nuebling, O'Reilly, Reber, Strockbine
Sayre: West, Wright
Scranton: Cox, Kneen, Nebelung, Taylor
Shamokin: Haupt, McWilliams
Shenandoah: Rassier
Shrewsbury: Giesey
South Williamsport: Barrick
Springdale: Pierce
State College: Sackett, Walker
Steelton: Litch
Stroudsburg: Holbrook
Sunbury: Rohrbach
Swarthmore: Fuller
Tyrone: Crawford
Upper Darby: Streander
Wayne: Pugh
Wilkes-Barre: Matter, Walker, Wintermute
Wilkinsburg: Fox, Hawley
Williamsport: Keliher, Wilhelm
York: Kable

CORPORATE

Allentown: Water Department
Bethlehem: City of Bethlehem
Easton: Northampton Consolidated Water Co.
Ellwood City: Ellwood Water Co.
Emporium: Emporium Water Co.
Erie: Commissioners of Water Works
Lewistown: Lewistown-Reedsville Water Co.
Milton: Pennsylvania State Water Corp., White Deer Mountain Water Co.
Reading: Bureau of Water
Scranton: Scranton Gas & Water Co.
Sharon: Shenango Valley Water Co.
Shenandoah: Commissioners of Water Works
Uniontown: Trotter Water Co.
Verona: The Suburban Water Co.
Washington: Citizens Water Co.
West Newton: West Newton Water Co.
Williamsport: Williamsport Water Co.

ASSOCIATE

Beaver Falls: Keystone Driller Co.
Berwick: Multiplex Manufacturing Co.
Bryn Mawr: Philadelphia Suburban Water Co.
Emaus: Donaldson Iron Co.

Erie: Hays Manufacturing Co.
Greensburg: Witt-Humphrey Steel Co.
Philadelphia: American Water Softener Co., M. L. Bayard, E. I. duPont de Nemours & Co., Kingsbury Machine Works, Inc., The Leadite Co., Inc., I. P. Morris Corp., The Pennsylvania Salt Manufacturing Co., Roberts Filter Manufacturing Co., Scofield Engineering Co., Simplex Valve & Meter Co., Talbot Non-Corrosive Linings Co., United States Cast Iron Pipe & Foundry Co., R. D. Wood & Co.
Pittsburgh: A. M. Byers Co., Dravo-Doyle Co., National Tube Co., Pittsburgh-Des Moines Steel Co., Pittsburgh Equitable Meter Co., Pittsburgh Testing Laboratory, Riter Conley Co.
Sharon: Penstock Construction Co.
Williamsport: The Darling Valve & Manufacturing Co.

RHODE ISLAND

Active 5; Corporate 1; Associate 1; Total 7

ACTIVE

Bristol: Jones
Providence: Bean, Bugbee, Gage, Richardson

CORPORATE

Providence: Water Maintenance Department

ASSOCIATE

Providence: Builders Iron Foundry

SOUTH CAROLINA

Active 10; Corporate 1; Total 11

ACTIVE

Camden: Chapman
Charleston: Gibson, Parker
Columbia: White
Easley: Rogers
Greenville: Blackwelder, Perry
Newberry: Schumpert
Spartanburg: Simms, White

CORPORATE

Charleston: Commissioners of Public Works

SOUTH DAKOTA

Active 3; Corporate 1; Total 4

ACTIVE

Huron: Hays
Sioux Falls: Connor
Vermillion: Hunter

CORPORATE

Sioux Falls: Water Works

TENNESSEE

Active 19; Corporate 2; Associate 3; Total 24

ACTIVE

Chattanooga: Lofton, Porzelius, Swearingen
Cookeville: Collier
Covington: Charter
Dyersburg: Blakeman
Fountain City: Murphy
Greeneville: McAmis
Kingsport: Webster
Knoxville: Switzer
Memphis: Allen, Dean, Mantel, Sullivan
Nashville: Clark, Fullerton, Harrub, Holman, Reyer

CORPORATE

Knoxville: Water Department
Memphis: Board of Water Commissioners

ASSOCIATE

Chattanooga: Columbian Iron Works
Knoxville: W. J. Savage Co.
Memphis: Layne & Bowler Co.

TEXAS

Active 29; Corporate 3; Total 32

ACTIVE

Austin: Avery, Bantel, Eggert, Ehlers, Green, Norris, Zilker
Beaumont: Bernhagen
Bonham: Whedbee
Dallas: Morey, Jr., O'Neil, Rosenthal, Wendler
Fort Worth: Hawley, Mahlie, Quigley
Freeport: Bushnell
Houston: Iglehart, McVea, Randolph
McAllen: Boyle
Mineral Wells: Smart

San Antonio: Bartlett, Newcomb
Waco: Bardwell, Gooch
Weatherford: Cherry
Wichita Falls: Curd, Ward

CORPORATE

Dallas: Dallas City Waterworks
Fort Worth: Texas-Louisiana Power Co.
Waco: Waco Water Works

UTAH

Active 5; Corporate 1; Associate 1; Total 7

ACTIVE

Brigham City: Roskelley
Provo City: Newell
Salt Lake City: Lyman, Male, Painter

CORPORATE

Salt Lake City: Water Department

ASSOCIATE

Provo: Pacific States Cast Iron Pipe Co.

VERMONT

Active 1; Total 1

ACTIVE

Burlington: Moat

VIRGINIA

Active 19; Corporate 2; Associate 4; Total 25

ACTIVE

Alexandria: Lambert
Covington: Barnett
Danville: Brantly
Denbigh: Bowers
Falls Church: Anderson
Fredericksburg: Houston, Jr.
Hampton: Engle
Lynchburg: Wagner
Newport News: Dugger
Norfolk: Bliven
Petersburg: Bunting
Portsmouth: Davis
Richmond: Baldwin, Bardwell, Claiborne, Messer, Smith, Snidow
Roanoke: Moore

CORPORATE

Alexandria: Alexandria Water Co.
Norton: Water Department

ASSOCIATE

Lynchburg: The Glamorgan Pipe & Foundry Co., Lynchburg Foundry Co.
Richmond: Sydnor Pump & Well Co., Inc., Virginia Machinery & Well Co., Inc.

WASHINGTON

Active 29; Corporate 4; Associate 1; Total 34

ACTIVE

Aberdeen: Stock
Anacortes: Short
Bremerton: Casad
Chelan: Harper
Everett: Klapp
Hoquiam: Austin, Dietrich, Heermans
Kelso: Hanley
Longview: Labsap
Mount Vernon: Wilson
Puyallup: Phillips
Seattle: Botten, Dorisy, Grant, Jacobs, Markhus, Miller, Osborne, Purcell, Shibley
Spokane: Harding
Tacoma: Blair, Kunigk, Roberts, Shaneman, Stannard
Vancouver: Clarke
Walla Walla: McLean

CORPORATE

Kelso: Water Department
Seattle: Water Department
Spokane: Water Division
Wenatchee: Water Department

ASSOCIATE

Seattle: Newman C. Jannsen

WEST VIRGINIA

Active 16; Corporate 3; Associate 1; Total 20

ACTIVE

Bluefield: Rhoads
Charleston: Musser, Tisdale
Chester: Young
Clarksburg: Boynton, Highland
Huntington: Johnson, Watt
Morgantown: Carpenter
Moundsville: Hetzer
Mullens: Kirby
Shinnston: Riffee
Weston: Blair, Jr.
Wheeling: Rickard, Shull, Stern

CORPORATE

Charleston: West Virginia Water Service Co.
Dunbar: Dunbar Water Co.
Morgantown: The Morgantown Water Co.

ASSOCIATE

Charleston: Raymond Equipment Co.

WISCONSIN

Active 38; Corporate 4; Associate 2; Total 44

ACTIVE

Antigo: Jackson
Appleton: Hall, Morris
Cedarburg: Schneider
Eau Claire: Brown
Fort Atkinson: Leonard
Janesville: Griffey
Kenosha: Hurtgen
Madison: Baker, Domogalla, Gallaher, Kirchoffer, Mead, Muegge, Smith, Thiessen, Warrick
Manitowoc: Schroeder
Marshfield: Marvin
Menasha: Kuester
Milwaukee: Bohmann, Cunliffe, Daniel, Gruetzmacher, Schwada, Wright
Monroe: Schneider
Racine: Peirce
Sheboygan: Donohue
Sparta: Erickson
Stoughton: Snyder
Superior: Corine, Lounsbury, Winslow
Waukeshaw: Hayford
Waupun: Barnett
Wauwatosa: Hebbring
Wisconsin Rapids: Gross

CORPORATE

Delavan: Water Commission
Fond du Lac: City Water Department
Green Bay: Water Department
Sheboygan: Board of Water Commissioners

ASSOCIATE

Milwaukee: Allis-Chalmers Manufacturing Co., Badger Meter Manufacturing Co.

WYOMING

Active 5; Total 5

ACTIVE

Casper: Fair
Gillette: Thomas
Rock Springs: Bell
Sheridan: Gwillim, MacCarty

CANADA

Active 124; Corporate 18; Associate 7; Total 149

ACTIVE

Brandon: Shaw
Brantford: Wilson
Brockville: Farquharson
Calgary: Breen
Carleton Place: Rogers
Charlottetown: McMillan
Cobourg: Skidmore
Cornwall: Lount
Dundas: Wright
Edmonton: Corbett, Owens, Turner
Elmira: Bowman
Galt: Cowan
Hamilton: Buchanan, Darling, McFaul, McRae
Hull: Lanctot
Ingersol: Hall
Islington: MacNicol
Kitchener: Pequegnat
Lindsay: Hammond
London: Brickenden, Buchanan, Ellwood, Hodkinson
Longueuil: Laforest
MacDonald College: Stephen
Montreal: Baudouin, Dorrance, Field, Gerin, Hunter, Hutchison, Jette, Lafreniere, Lea, LeSage, Leslie, McCrady, Meadows, Montabone, Perry, Pitcher, Plamondon, Scofield, Ward
New Toronto: Thomas
Niagara Falls: Acres, Ferris, Warder
North Bay: Mackie
Orillia: Starr
Oshawa: Smith
Ottawa: Ferguson, Macallum, MacDonald, McRae
Owen Sound: Pratt
Pembroke: Howe
Perth: Smith
Peterborough: Dobbin, Hunt
Quebec: Casgrain, Lessard, Tremblay
Regina: Farrell
St. Catharines: Milne

St. James: Pilgrim
St. Lambert: Le Royer
Sault Ste. Marie: Belyea
St. Stephen: Laflin
St. Thomas: Miller
Sarnia: Hall
Shawinigan Falls: Vermette
Simcoe: Kirkwood
Southend: Pringle
Stratford: Myers
Strathroy: Smithrim
Temiskaming: Grimmer
Toronto: Allen, Angus, Austin, Berry, Bradshaw, Chipman, Coles, Dallyn, Delaporte, Gaby, Gore, Hannan, Harris, Harrison, Heath, Howard, Jack, Proctor, Redfern, Routledge, Salmond, Sanderson, Storrie, Thompson, Van Benschoten, Walker, Wilkinson Wynne-Roberts
Vancouver: Brakenridge, Cleveland, Dowling, Greig
Walkerville: Brown
Wallaceburg: Caughey
Waterloo: Schiedel
Welland: Scott
Weston: Peirson
Windsor: Hanna, Keith, Kellner
Winnipeg: Hooper, Scott
Woodstock: Archibald

CORPORATE

Brampton: Water Commission
Brantford: Water Commissioners
Chatham: Board of Water Commissioners
Gananoque: Water Works Commission
Grimsby: Water Commission
Guelph: Water Department
Kitchener: Water Commission
Leamington: Corporation of Town of Leamington
London: Public Utilities Commission
Merritton: Water Works Department
Midland: Public Utilities Commission
Peterborough: Waterworks Department
Regina: Waterworks Department
St. Marys: Board of Water, Light & Heat Commission
St. Thomas: Water Commission
Welland: Board of Water Commission
Whitby: The Public Utility Commission
Windsor: The Water Commissioners

ASSOCIATE

Montreal: Francis Hankin & Co. Ltd., Jenkins Bros., Ltd.
Toronto: The Canadian Engineer, Drummond, McCall & Co., Ltd., Hugh C. MacLean Publications, Ltd., National Iron Corp., Ltd.
Windsor: The Canadian Salt Co., Ltd.

FOREIGN (Except Canada)

Honorary, 1; Active, 92; Corporate, 8; Total 101.

HONORARY

ENGLAND

London: Houston

ACTIVE

ARGENTINE REPUBLIC

Buenos Aires: Bado, Berrino, Lasso, Negri, Paitovi, Robertson, Soler
Mendoza: Ivanissevich
Parana: Laurencena
Rosario de Santa Fe: Buchanan, Gache, Moir
San Nicholas: Hudson

AUSTRALIA

Brisbane: Chamberlain, Peart
Melbourne: Hughes, Hume, Ritchie, Sutherland
Midland Junction: Limb
Mt. Charlton, Queensland: Symonds
Newcastle: Ewing
Perth: Haywood
Sydney: Blain

BRAZIL

Campos: Vieira
Rio de Janeiro: De Brito

CANAL ZONE

Ancon: Bunker, Hatch
Cristobal: Dunn
Gatun: Beers, Jr.

CHILE

Santiago: Lira, Stalbird

CHINA

Amoy: Mar
Shanghai: Gaunt, Michau, Pearson
Tientsin: Clark, Lilly

COLOMBIA

Bogota: Tanco
Bucaramanga: Castro
Cartagena: De la Vega

COSTA RICA

Heredia: Saenz

CUBA

Havana: Cosculluela, Martinez, Montoulieu

CZECHOSLOVAKIA

Prague: Purkyne

DENMARK

Copenhagen: Jarvis

ENGLAND

Birmingham: Dixon
Bradford: Mitchell
Buxton: Race
Coventry: Morgan
Dewsbury: Holdsworth
London: Cameron, Howland, Paterson
Manchester: Hill
Newport: Spencer
Northwich: Jones

FRANCE

Nancy: Paul
Paris: Dienert, Pain

GERMANY

Berlin: Ornstein
Breslau: Meinecke
Dresden: Vollmar

GREECE

Athens: Gausmann

HAWAII

Honolulu: Anderson, Tay

HOLLAND

Utrecht: Massink, Meerburg

HUNGARY

Budapest: Vojcsik

INDIA

Bombay: Bunting
Calcutta: Walker
Gwalior: Prokofieff

ITALY

Brescia: Franchi
Firenze: De Horatiis

JAPAN

Osaka: Takeuchi
Tokyo: Inoue, Iwasaki, Nishioeda

MEXICO

Torreon: Robles

PHILIPPINES

Manila: Gideon

POLAND

Warsaw: Geupel

RUSSIA

Leningrad: Timonoff

SANTO DOMINGO

Santo Domingo: Adams, McIntosh

SCOTLAND

Ayr: Ball

SOUTH AFRICA

Durban: Metcalfe

SPAIN

Cartagena: Bustelo

STRAITS SETTLEMENTS

Singapore: Tomlinson

SWEDEN

Stockholm: von Greyerz

URUGUAY

Montevideo: Altoberro, Maggiolo

CORPORATE

ARGENTINE REPUBLIC

Buenos Aires: Obras Sanitarias de la Nacion

Parana: Obras Sanitarias of Entre Rios

AUSTRALIA

Sydney: Metropolitan Water, Sewerage and Drainage Board

CUBA

Havana: Negociado de Acueductosy Alcantarillado

HAWAII

Honolulu: Dept. of Public Works

Oahu: Wahiawa Water Co., Ltd.

HOLLAND

Utrecht: Utrechtsche Waterleiding-Maatschappij

SWEDEN

Malmo: Malmo Byggnadskontor

SUMMARY BY STATES

	Active	*Corporate*	*Associate*	*Honorary*	*Total*
Alabama	14	2	3		19
Arizona	5	1			6
Arkansas	3	3			6
California	169	19	30	1	219
Colorado	28	6	3		37
Connecticut	22	3	2		27
Delaware	7				7
Dist. of Col	13				13
Florida	55				55
Georgia	18	2	2	1	23
Idaho	5	2			7
Illinois	153	8	26	2	189
Indiana	49	3	3	1	56
Iowa	48	3	4	1	56
Kansas	13	3			16
Kentucky	29	5	1		35
Louisiana	10	2		1	13
Maine	11	1			12
Maryland	36		1		37
Massachusetts	59		9	2	70
Michigan	60	7	4		71
Minnesota	43	3	2	1	49
Mississippi	3				3
Missouri	54	1	1		56
Montana	25	2			27
Nebraska	9	2	2		13
Nevada	2	1			3
New Hampshire	3	1			4
New Jersey	122	11	9		142
New Mexico	2	3			5
New York	295	30	59	3	387
North Carolina	75	1	1		77
North Dakota	3	1			4
Ohio	92	9	15		116
Oklahoma	11				11
Oregon	17	1	2		20
Pennsylvania	166	18	28		212
Rhode Island	5	1	1		7
South Carolina	10	1			11
South Dakota	3	1			4
Tennessee	19	2	3		24
Texas	29	3			32
Utah	5	1	1		7
Vermont	1				1
Virginia	19	2	4		25
Washington	29	4	1		34
West Virginia	16	3	1		20
Wisconsin	38	4	2		44
Wyoming	5				5
Canada	124	18	7		149
Foreign (except Canada)	92	8		1	101
October 1, 1928	2124	202	227	14	2567
October 1, 1927	2115	204	226	14	2559
Gain or loss in year	9	2	1		8